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UNIT TRAINS IN WESTERN CANADA

by

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled:

UNIT TRAINS IN WESTERN CANADA

submitted by: G. J. du Cloux

in partial fulfilment of the requirements for the degree of Master of Science

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ABSTRACT

This study deals with the position of unit train transportation in western Canada and discusses the concepts underlying unitized railroading in comparison with traditional methods. It surveys unit train systems as applied and as possible with regard to the movement of dry bulk commodities in the four western provinces in view of product origin, route, destination and utilization.

Some cost aspects of unit train systems are dealt with, as is the presence of competing technology. The application of the system in connection with the movement of coal is discussed in depth because of the interconnection between the growth in the movement of that commodity and the proliferation of unit trains. However, consideration is given also to this type of transportation for sulfur, potash, forest products and grain.

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Sincere gratitude is expressed for the patient and constructive guidance and assistance received from Dr. V. B. Proudfoot and Dr. N. R. M. Seifried, Professors of Geography, during the preparation and writing of this manuscript.

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CHAPTER I

INTRODUCTION

During the last decade it has been more fashionable than ever before in the twentieth century to question institutions and their operations in terms of relevance and usefulness to the benefit of the general public or segments thereof. In many cases this scrutiny has produced valid and valuable results, but with such widespread criticism, it is obvious that suggestions for change are not always made by knowledgeable individuals, and that they are frequently not impartially technical in nature, which again interferes with their usefulness. The railroad companies on this continent have not escaped the attacks of a variety of individuals and pressure groups. Doubts have been raised concerning relationships between these transportation systems and the rest of the economy. Opinions have ranged from extremely negative to very positive with regards to the present function of ground transportation organizations; however, negative views upon their usefulness seem to prevail, if one can judge by the daily press. Few suggestions for improvement

are made, and of these even fewer are based on a knowledge of the problems involved.

The present study focuses on some recently developed or proposed improvements in dry-bulk, long-distance ground transportation, that is "unitized railroading," in the four western provinces. These improvements may serve as an illustration of changes that can be made within an existing system. The emphasis will fall on the relatively new tendency toward integrated movements, while relevant alternative modes will also be considered.

The information used was acquired from discussions with company officials, by correspondence from a number of transportation companies containing both public and confidential data, from sources such as Statistics Canada and the Alberta Energy Resources Conservation Board, and from general literature. It was found that, aside from some aspects of integrated rail transportation, relatively little has been written about this subject, but that much research is at this time in progress, sponsored by both private and public sectors. Another factor compounding the difficulties in the collection of pertinent data was the fact that, even though the purpose of the correspondence was clearly indicated, and although confidentiality was guaranteed wherever necessary, several companies were not willing to disclose certain

crucial aspects of their operations. In some cases this information had to be either inferred from the general literature, or derived from other sources. Finally, it was noted that a number of businesses which would not commit their information to paper would, in principle, be willing to convey these facts via personal interviews. Identification of confidential data sources has been avoided, as were the sometimes untraceable origins of ideas which accumulate during perusal of literature.

Two major stumbling blocks in obtaining information on unitized railroading, although of a different nature from those mentioned before, were the apparent lack of knowledge among railroad people concerning the finer details and gradation in unitization, as well as the partially foreseen,but never fully realized state of uncertainty about rates and feasibilities in unitized railroading due to pronounced changes in the price and availability of energy supplies across the world.

Traditionally the railroads have grown with the country and vice-versa[1]. Through its entire history the railway system has developed in response to pressures of political, economic and widely varying industrial natures, and there is no reason to believe that it will not continue to do so.

Reacting to precisely such stimuli the railways have

recently developed a new system for moving large amounts of payload which will, and indeed has already, come to cause considerable changes on the transportation scene. It is at this point that the new methodology enters the scope of interest of transportation geography.

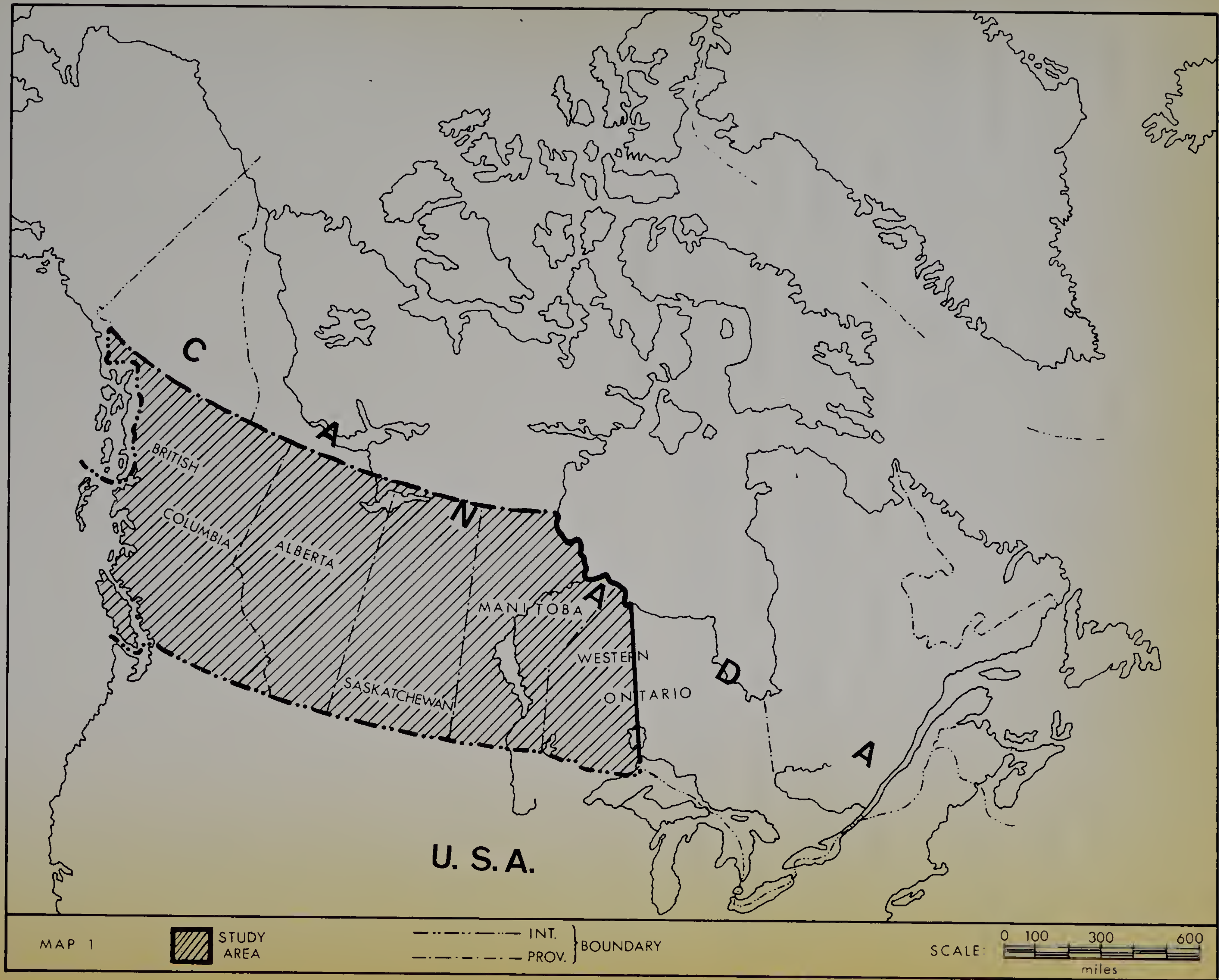
As Cole and King[2] point out, the subject matter of geography is very diverse, and in parallel with the majority of the social and physical sciences, the boundaries are rather diffuse, encompassing many aspects in common with other disciplines. It is therefore necessary to define for each subject of study in transportation geography, as well as possible, the limitations in space and scope of interest.

The space dealt with in this particular study is limited to the four western provinces of Canada plus a small part of western Ontario (Map 1) for the following reasons:

a. the topical nature of the subject in this part of the country,
b. accessibility and existence of information,
c. convenient demarcation in terms of rail transport,
d. the presence of certain commodities which fit conveniently within the scope of interest of this study.

Some examples from beyond the study area will be quoted, however, when they appear relevant to the subject.

The scope of the study has been carefully constricted to fall within the geographer's sphere of interest without straying too deeply into, for example, such detailed


C
A
N
A
D
A
U. S. A.
BRITISH
COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
WESTERN
ONTARIO
STUDY AREA
INT.
PROV.
BOUNDARY
SCALE:
0
100
300
600
miles

MAP 1

technical workings which would more properly belong to the field of engineering. However, certain overlaps with other disciplines are unavoidable when defining the focal points as being the methods of transport, the spatial interactions, the commodities involved as well as their distribution, the nature of the problems to be overcome and the alternatives left open by the new developments.

The approach taken in the project has by choice been somewhat historical and technical since the subject of the study is essentially the development of a certain aspect of a dynamic system which relies heavily on inputs from innumerable disciplines.

FOOTNOTE REFERENCES

[1]G. P. de T. Glazebrook, *A History of Transportation in Canada, Vol. I, II.*

Robert F. Legget, *Railroads in Canada.*

[2]J. Cole and C. King, *Quantitative Geography*, Ch.1, Sec. 1, 2.

CHAPTER II

CONVENTIONAL LONG DISTANCE RAIL OPERATIONS IN WESTERN CANADA

1. THE WESTERN RAIL NETWORK

When British Columbia agreed to join the Canadian confederation it was finally persuaded to do so by the promises of the new Dominion Government to link the cities of the east with the west coast. At that time Canada's population amounted to a mere three-and-a-half million of whom only 23,000, not counting Indians, lived west of Lake Superior[1], and the task of building a railroad across the continent was huge and costly indeed. Under continued pressure from British Columbia, out of fear of growing American influence in the west, and amidst political and financial scandals the first company to be incorporated with the specific task of completing the trans-continental link was the Canadian Pacific Railway Company in the year 1880[2].

From then on railroad construction created, at an accelerating rate, a network for the Canadian Pacific as

well as for a number of other successfully established companies. The growth pattern of the network is reminiscent of that in contemporary underdeveloped countries as described by Taaffe, Morrill and Gould[3]. Morrill later summarized such development and emphasized the process of limited penetration of the inland areas, consolidation of ports with the growth of local feeders and additional nodes, as well as, eventually good direct routes and efficient lateral connections according to the needs of the developing areas[4]. Present day development still indicates a parallel process in extending rail transportation routes into the "northern frontier" area. For the railroad system this network constitutes the basic requirement for carrying out its business.

The rail transportation system is essentially an open system, that is, subject to interaction with its environment, and therefore can be defined by the following:

1. A set of elements identified with some variable attribute of objects,
2. A set of relationships between the attributes of objects,
3. A set of relationships between those attributes of objects and the environment[5].

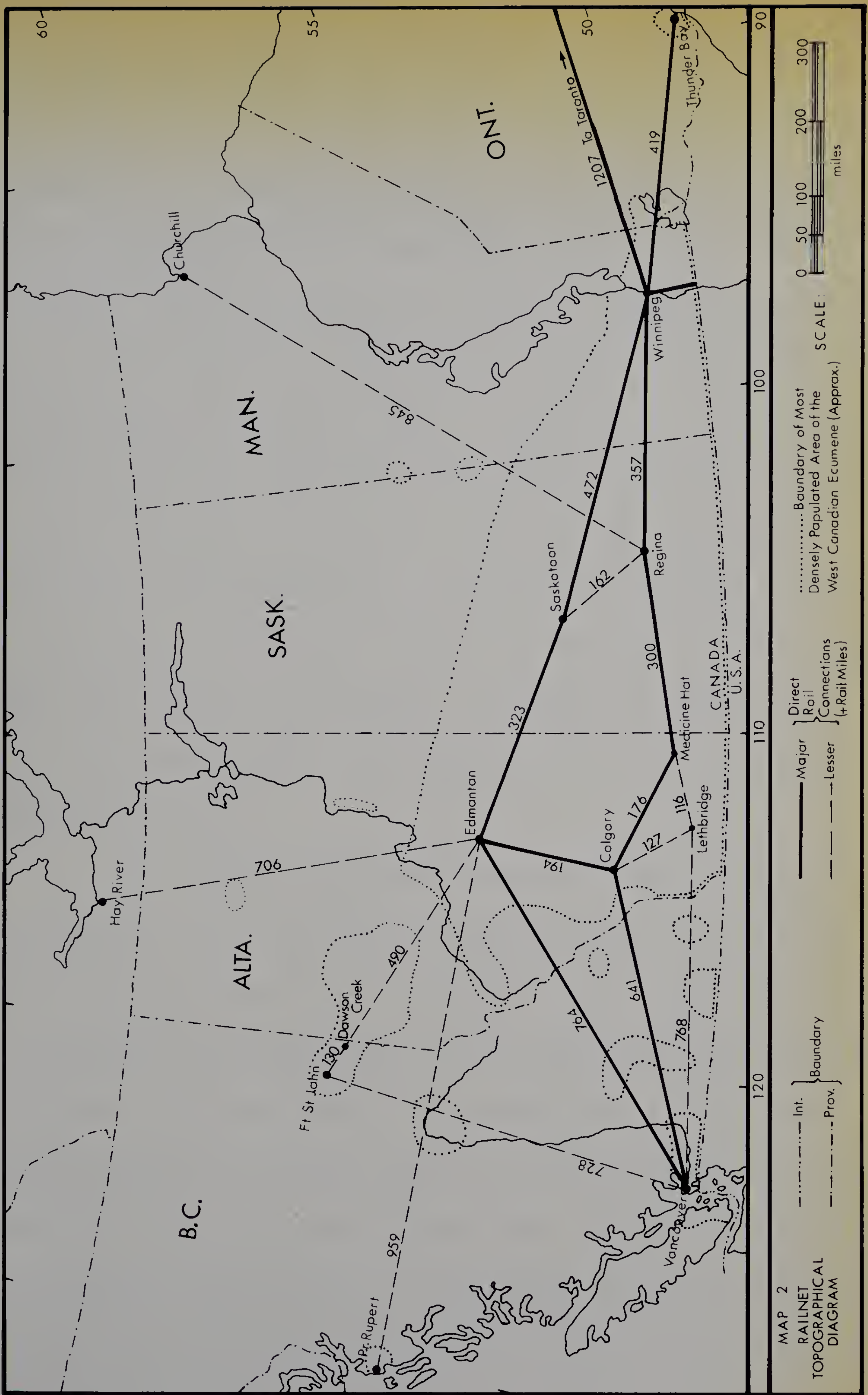
At a lower level of analysis an element may constitute a system by itself, and its behavior can provide a field of study in its own right, whence one can move further down

the line to innumerable sub-systems.

The railroad system is part of a larger context and has, in turn, a number of sub-systems of which the following elements are perhaps most important, albeit in arbitrary order: the rail network, the rolling stock, terminal facilities and shops, personnel and the organization. The condition and behavior of each element should be investigated in order to understand the behavior of the system which is concerned with "flows, stimuli and responses, inputs and outputs."[6]

For the understanding of a network and its description characteristics and criteria have to be established. One can describe networks, or nets[7], in general as systems (or collections) of points (nodes) connected by links (arcs); networks may be incomplete, undeveloped or interrupted. Nodes may be inserted along arcs at later stages, thus affecting various network qualities. Areas enclosed by arcs are called regions, while arcs which do not enclose regions are termed branches (Map 2). Cole and King[8] and Morrill[9] mention furthermore a number of characteristics which can be used for network description; a few of these will be used throughout the text.

The western railnet, as limited for study purposes,



MAP 2
RAILNET
TOPOGRAPHICAL
DIAGRAM

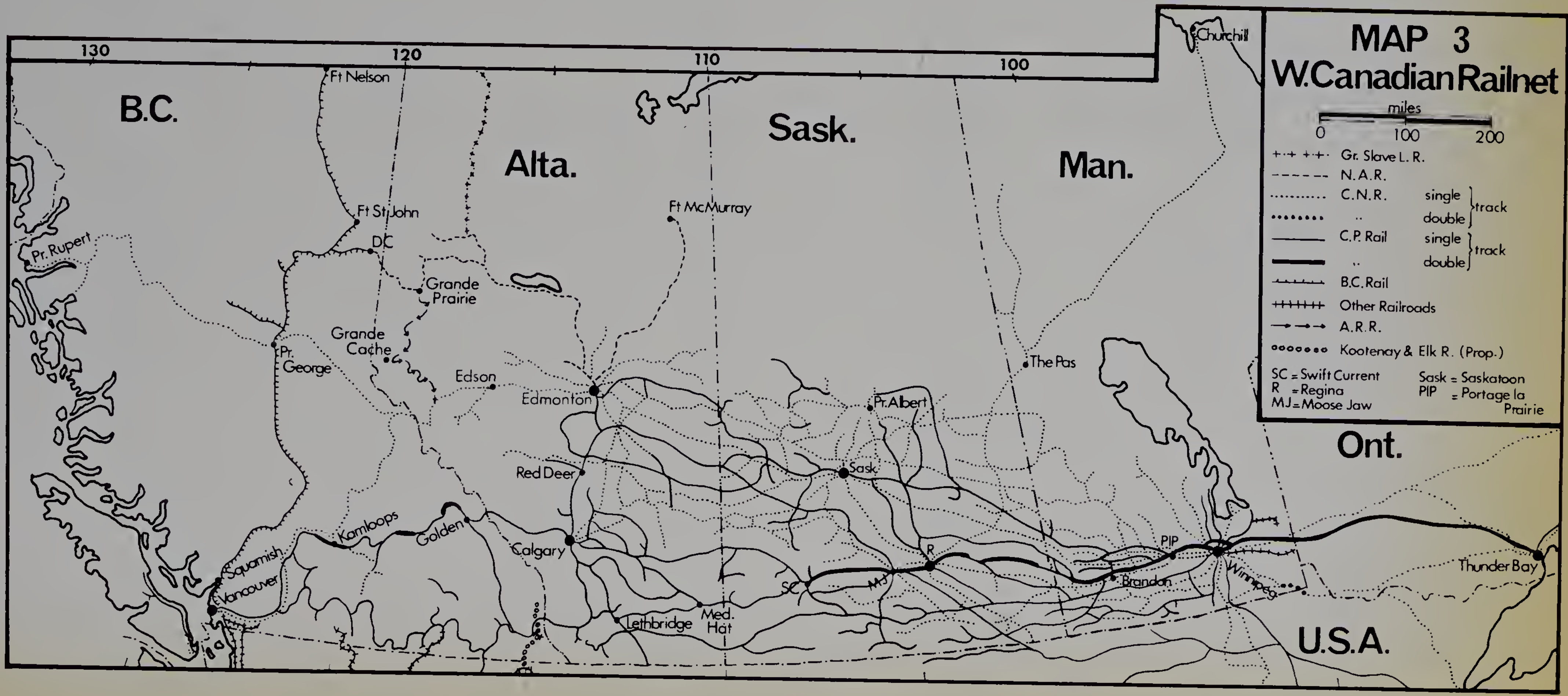
stretches from Thunder Bay (formerly Port Arthur and Fort William) to Vancouver, both major terminals for commodity movements. It coincides rather closely with the western half of the most densely populated part of the Canadian ecumene[10] (Map 2), although a number of branches extend, for various purposes, into the more sparsely populated areas along the northern edge of settlement. On the prairies it thus coincides generally with the area south of the agricultural frontier as shown in the Atlas of the Prairie Provinces (p.13 of Atlas). In fact the railnet is truly a sub-system of this part of the ecumene since it has grown with the country in a fashion, as Fogel[11] suggests, of "spurring development and responding to economic and political stimuli."

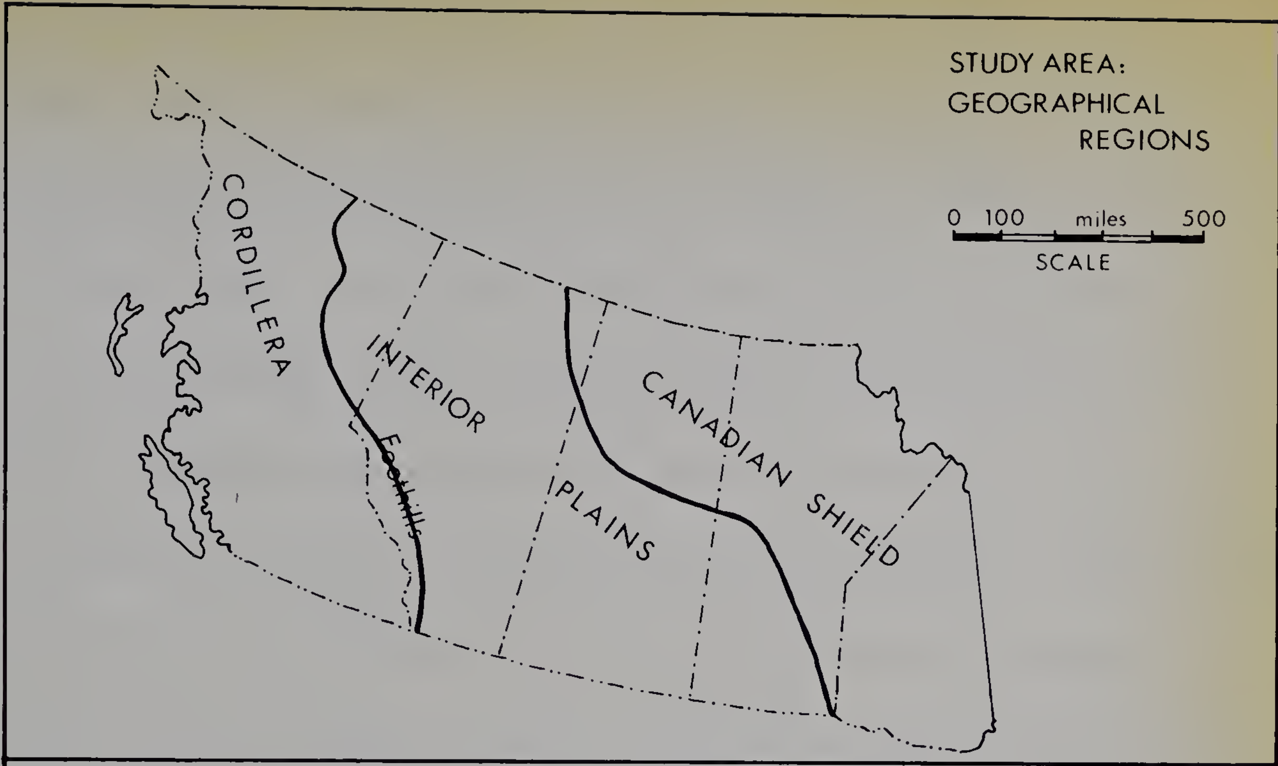
The simple topological diagram of Map 2 suggests an elongated fish shape for the main connecting parts of the system, oriented in an east-west direction, which is in agreement with the ideas which caused the railroads to move into the area, namely, to connect the two extreme settled parts of the new Dominion transcontinentally over national territory. The network has, however, developed considerably since then; in the center and along the northern fringe specifically to serve the various regional

economic interests. For this latter reason one also finds several branch lines extending quite far beyond the general service area (Map 3), all coinciding with the desire lines for shipment of goods (and passengers) as they developed over the decades.

The territory covered by the network contains three major geographical regions (Map 4) which are easily distinguishable by their varying surface features; they are, from east to west, the Canadian Shield, the Interior Plains and the Cordillera. Detailed descriptions of these areas fall beyond the scope of this work and can be assessed from many publications and atlases, but certain relevant characteristics ought to be mentioned in connection with the network under discussion.

The Canadian Shield covers the eastern part of the study region and is recognizeable by its environmental traits of exposed and bare Precambrian rocks, jutting out in the form of hills which generally reach no higher than a few hundred feet above the valleys which, in turn, are filled with glacial deposition. The limited area crossed by railways (in western Canada) contains few obstacles facing the system except for minor rock protuberances and long distances. There are large areas of forest and innumerable lakes, but only some areas are mineralized, relatively few


MAP 3
W.Canadian Railnet
miles
0 100 200
Gr. Slave L. R.
N.A.R.
C.N.R. single track
" double track
C.P. Rail single track
" double track
B.C. Rail
Other Railroads
A.R.R.
Kootenay & Elk R. (Prop.)
SC = Swift Current
R = Regina
MJ = Moose Jaw
Sask = Saskatoon
PlP = Portage la Prairie
130
120
110
100
B.C.
Alta.
Sask.
Man.
Ont.
U.S.A.
Churchill
Ft Nelson
Ft St John
DC
Grande Prairie
Grande Cache
Pr. Rupert
Pr. George
Edson
Edmonton
Ft McMurray
Red Deer
Calgary
Golden
Kamloops
Squamish
Vancouver
Lethbridge
Med. Hat
SC
MJ
R
Sask
Pr. Albert
The Pas
PlP
Brandon
Winnipeg
Thunder Bay



MAP 4

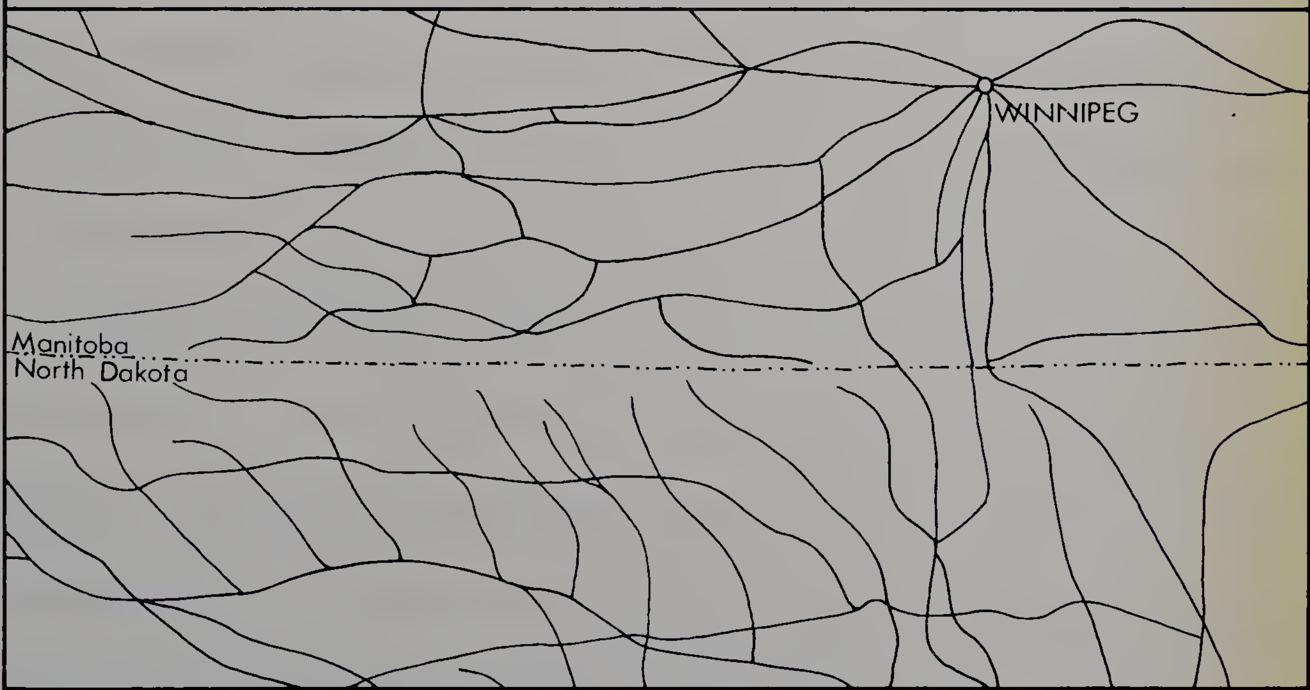
——— Limits of Geographical Regions (D.B.S.)
—·—·— Prov. Boundary
—··—··— Int. Boundary

MAP 5 CANADA – UNITED STATES BORDER AREA

SOURCE: Alexander

——— Railroad
—··— Int. Boundary

25 miles
SCALE



people live there and farming is virtually absent.

The Interior Plains, or central section, is by no means flat although it is thought of as the largest area of nearly level land in the country. Moving from the eastern part into the Plains one crosses an escarpment of Cretaceous rocks, after which one enters an area of other sedimentary rocks and lacustrine soils. The surface is flat in parts and undulating in others. It used to be covered with coniferous and mixed forests through the northern half and with grasses of various lengths in the south. At present, the original grasslands and the southern parts of the forest region are covered primarily by farmland, rangeland (in the west) and some wasteland. They contain the bulk of the prairie population and have considerable mineral wealth, of which oil and gas, coal and potash are the most important. Transportation networks are faced with even fewer obstacles than on the Canadian Shield, other than the deeply incised major river valleys.

The Cordillera region comprises the third and most westerly part. It contrasts sharply with both previous sections. Starting immediately west of the Alberta foothills is a mountainous region composed of numerous ranges running parallel with and continuing to the west coast. It is characterized by sharp contrasts within small areas in

physical attributes, population densities and economic activity. The rocks are primarily of Precambrian, Paleozoic or Mesozoic origin, reaching great heights and leaving few areas of level land. Many subregional landforms can be outlined, but in this context it will suffice to state that the ranges and their valleys, extending generally in a northwest-southeasterly direction, have always tended to block passage from the plains to the coast. The east-west orientation of the transportation networks, and especially the railroad, is still present but distorted by the physical barriers. As agriculture and settlements tended to be established in the few available valleys, so did transportation, except where it was forced to, and able, to find passes of reasonable height and grades. The mineral wealth of the Cordillera has enticed many entrepreneurs to enter into the lesser accessible areas and, consequently, long circuitous routes are common, distorting the picture presented by most simple connectivity and directness analyses.

While the environmental factors mentioned above are relevant to almost all transportation networks, some specific climatic conditions tend to affect the railnet to a somewhat greater extent than other communication nets. For example, in areas where high precipitation or extended

periods of ground wetness can create hazardous support for the relatively narrow roadbed with its intermittent high loads, alternate locations have to be found. Mistakes can be made even though this consideration is well known, as the 1972 swamping of the A.R.R. line between Grande-Cache and the C N main line exemplifies.

The Canadian railnet began with the 1836 opening of a few miles of track between Laprairie and St.Johns (Que.), operated by the Champlain and St. Lawrence Railroad; for almost half a century most further development occurred in the eastern part of the country. The western part of the network got started within the decade after Confederation and railroad construction boomed through the first quarter of this century, especially during the time of the formation of the prairie provinces which was made possible by the huge influx of immigrants. According to Graham[12] the area from Winnipeg to the foothills of the Rocky Mountains increased its population from approximately 12,000 (not counting Indians) in 1870 to more than 1,300,000 in 1911.

During the early years of the twentieth century there was a flurry of railroad building, as well as for some time after the first World War. During these periods the prairie network with its numerous branchlines was completed.

By approximately 1935 the Canadian network as a whole had reached a leveling-off point with roughly the same track mileage as at present (Fig. 1). Abandonment and new construction have kept it at the level of 43,000 miles (Table 1A). This mileage makes it, in size, the third largest in the world, behind the U.S.A. and the U.S.S.R. with approximately 250,000 and 60,000 miles respectively. An interesting statistic is that, in comparison with the United States, Canada supports per citizen approximately twice the road mileage, which gives some indication of the expense of maintenance and operation with respect to the neighbour to the south. Slightly more than half of the main track mileage in Canada is in the Study Area with its very small population (Table 1B).

Most of the rapid expansion at the beginning of the century resulted in excessive mileage on the prairies[13] which is still burdening the railroads today as is illuminated by Purdy who determined that 47 percent of the western region trackage was branchline and contributed only approximately five percent of the ton-mile traffic. Furthermore he states that between 1926 and 1959 branchline traffic only showed modest increases while mainline density more than doubled.

FIG. 1 MAIN RAILWAY TRACK MILEAGE OPERATED IN CANADA

SOURCE: D.B.S. and Purdy

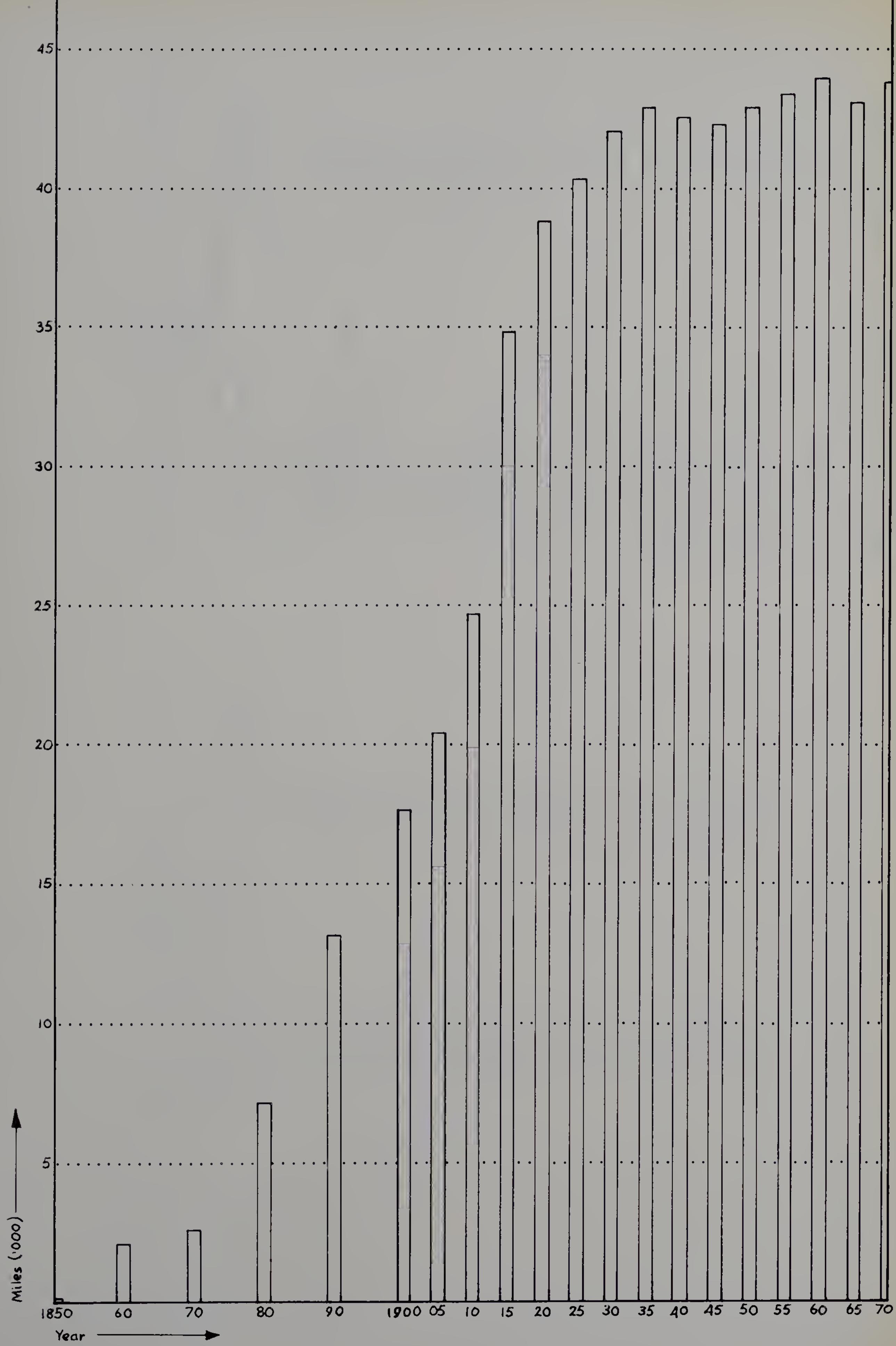


Table IA
Main Railway Track Mileage Operated
In Canada
(source: D.B.S. + Purdy)

Year A.D.	Miles in Operation
1850	66
1860	2,065
1870	2,617
1880	7,194
1890	13,151
1900	17,657
1905	20,487
1910	24,731
1915	34,882
1920	38,805
1925	40,350
1930	42,074
1935	42,916
1940	42,565
1945	42,352
1950	42,979
1955	43,444
1960	44,029
1965	43,157
1970	43,983

Table 1B
Railway Track Mileage by Area and Type
1970
(source D.B.S.)

Type and Area	Mileage
First Main	
Newfoundland	944
Pr. Edward Island	254
Nova Scotia	1,301
New Brunswick	1,665
Quebec	5,329
Ontario	10,038
Manitoba	4,746*
Saskatchewan	8,565*
Alberta	6,245*
British Columbia	4,370*
Yukon Territories	58
North West Territories	129
U.S. owned	339
Total First Main	43,983
Second Main	1,954
Other Main	64
Industrial	1,498
Yard and Sidings	12,130
Joint Track	140
Grand Total	59,769

*Manitoba, Saskatchewan, Alberta and B.C. have 23,926 First Main Miles, i.e. 54.4% of National Total

One of the reasons for the rail pattern on the prairies is obviously the strong local orientation of many branch lines which were built for the purpose of serving agricultural needs in restricted areas. The result is frequently difficult connections with mainlines and often, as along the U.S. border, no through connections with similar neighboring regions with identical economies (Map 5)[15].

A few other aspects of the network should be noted. First of all there is the almost total absence of double track[16] (Map 3). CP Rail is the only operator of significant lengths of double track but this forms only a minor portion of its network, which in the west is approximately the same size as that of the Canadian National. On a national scale CN is first in size with about 23,000 miles of track, C.P. Rail is second with close to 16,000 miles[17].

Both of these companies make up the Canadian Class I railways and accounted for 87.4 percent of total railway revenue in 1970 (CN: 50.7%, CP: 36.7%; source: Statistics Canada). They own or operate the bulk of the western trackage. The British Columbia Railway (formerly the Pacific Great Eastern Railway) is fourth on the national scale but third in the west with approximately 1.8 percent of total revenue. Table II provides information on those

Table II- Canadian Companies Owning and Operating on the Western Railnet
Sources: Statistics Canada, Purdy, Currie, Financial Post

Class	Definition	Railway Company	Track Location	Ownership
I	By definition the two major carriers	Canadian National*	Entire Study Area	Federal Govt; Public
		CP Rail*	" " "	Private
II	Annual revenues of $500,000 or more	B.C. Rail*	North-South through B.C.	Provincial Govt
		Northern Alberta Ry*	Northern Alberta	CN and CP Rail
III	Annual revenues of less than $500,000	Alberta Resources Ry*	N.W. Alberta	Prov Govt (CN operated)
		Gr. Slave Lake Ry*	N.Alberta into NWT	CN
		Greater Winn.Water Dist. Ry	S.E. Manitoba	Provincial Govt
		Winnipeg City Power Tramway	" "	" "
		B.C. Electric Ry*	B.C. Lower Mainland	B.C. Hydro & Power Auth. (Prov. Govt)
		Morrissey, Michel & Ferny Ry	B.C. Crowsnest Area	Crows·Nest Indus. Ltd.
		Kootenay & Elk Ry (planned)	" " "	
IV	Terminal Bridge & Pullman Companies			

Only the companies marked * in Table II will be dealt with later in this study

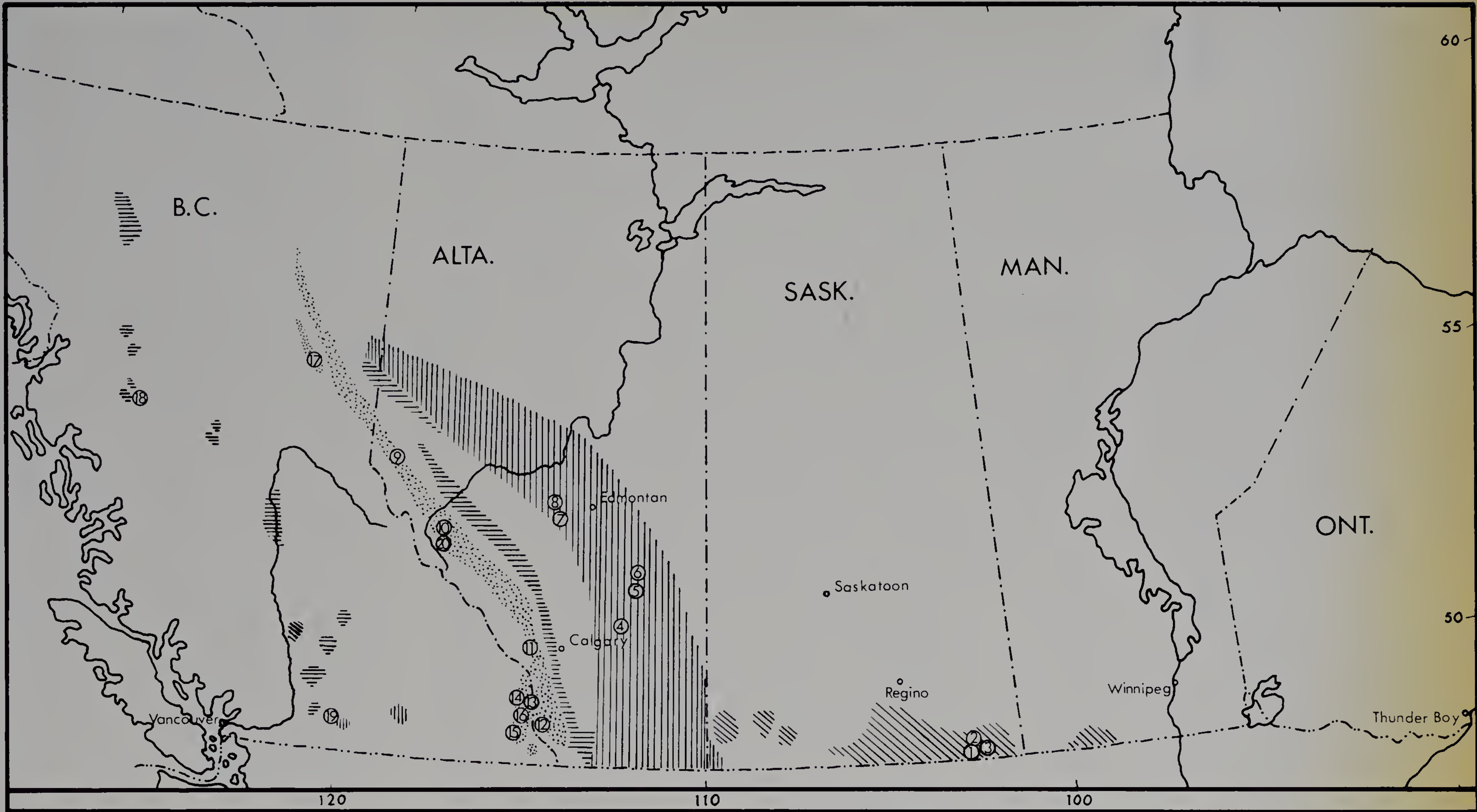
of Canada's roughly thirty railroad companies which operate within the Study Area. Only the companies marked * in Table II will be dealt with later in this study.

2. PARTICULARS AND MOVEMENTS OF SELECTED COMMODITIES

Since the emphasis of this study is on unitized rail transportation, only those commodities which seem, under present conditions, best suited to this mode of transport are considered here. These commodities are: coal, sulfur and potash. Two other important western commodities, grain and forest products, are considered to a lesser extent in a later chapter, while mention is also made of some products, such as phosphate rock, which are moved only in limited quantities.

<u>Coal.</u>--

Coal occurs in many parts of the study area (Map 6) and appears in a number of forms which have been classified into several main groups, each of which has specific major uses. The classification system developed by the American Society for Testing and Materials (ASTM) and adopted by both Canada and the U.S. is represented in Fig. 2. On the basis of the ASTM ranking, qualities and locations of many diverse types of coal in North America are known and proven, probable and inferred reserves have been calculated.



MAP 6

Coal Areas of Western Canada
With Principal Mines

Prav. } Boundary
Int.

For Expanded Legend Refer
ta the Fallowing Page.

SCALE: 0 50 100 200 300 miles

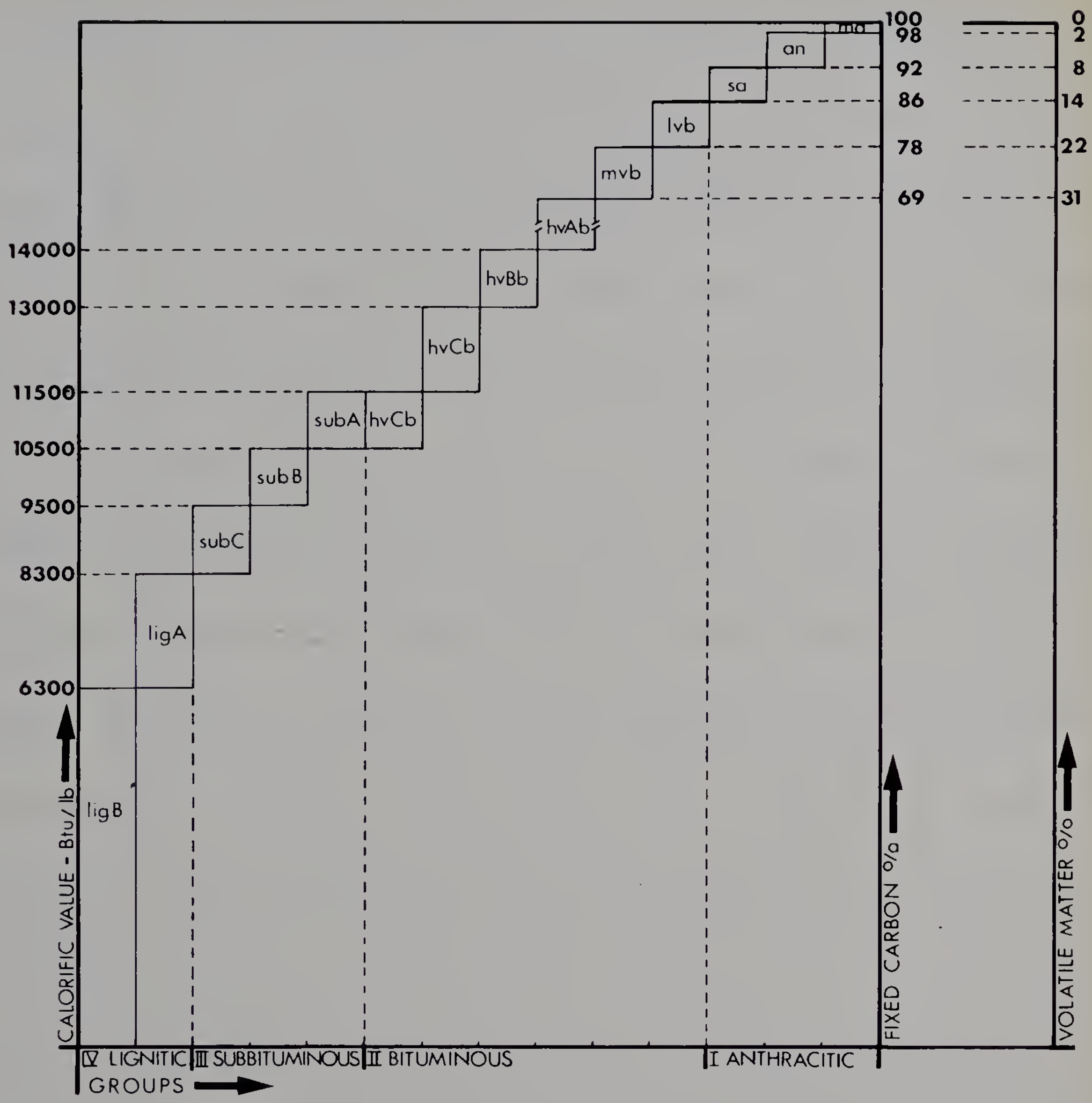
Legend Map 6

Sources: Research Council of Alberta, Energy Resources Conservation Board, Alberta Bureau of Statistics, Canadian Mining Journal.

Low and Medium Volatile Bituminous Coal (Including Anthracite)
High Volatile Bituminous Coal
Subbituminous Coal
Lignite

1. Alberta Coal Ltd. (lignite)
2. Manitoba and Saskatchewan Coal Company Limited (lignite)
3. Utility Coals Ltd. (Lignite)
4. Alberta Coal Ltd. (Subbituminous)
5. Alberta Coal Ltd. (Subbituminous)
6. Forestburg Collieries Ltd. (Subbituminous)
7. Alberta Coal Ltd. Highvale Mine (Subbituminous)
8. Alberta Coal Ltd. Whitewood Mine (Subbituminous)
9. McIntyre Porcupine Mines Ltd. (Low Vol. Bituminous)
10. Cardinal River Coals Ltd. (Med. Vol. Bituminous)
11. The Canmore Mines Ltd. (Low Vol. Bituminous; Anthracite)
12. Coleman Collieries Ltd. (Med. Vol. Bituminous)
13. Scurry Rainbow Oil Limited and Emkay Canada Natural Resources Ltd. (Low and Med. Vol. Bit.) In Preparation
14. Fording Coal Limited (Low and Med. Vol. Bit.)
15. Kaiser Resources Ltd. (Low and Med. Vol. Bit.)
16. Crows Nest Industries (Low and Med. Vol. Bit.)
17. Brameda Resources Limited (Low Vol. Bit.) In Preparation
18. Telkwa District: High activity by various companies in exploration
19. Princeton District: Active exploration, various
20. Gregg River Resources Ltd. (Manalta Coal Ltd.)(Med. Vol. Bit.) In Preparation

Some areas and many mines have been omitted because they are either considered to be mined out or of no significance within the near future for the purposes of this study. It should be noted that the following companies in particular are actively exploring the Alberta foothills area: Canpac Minerals Ltd., Master Explorations Ltd., Denison Mines Limited, and Scurry Rainbow Oil Limited.



The classification of each coal ranges from (incl.) the lower placed figure on the scale to (not incl.) the higher placed figure.

For letter code refer to TABLE IV.

FIG. 2 CLASSIFICATION OF COALS BY RANK (Adopted from A.S.T.M.)

Table III indicates the various ranks of the coal, their presence and qualities in the west, as well as some major uses.

Most of the coal mined in the west used to be sold for railway fuelling, domestic heating and steam raising for power generation. By the early 1950's, however, only steam raising remained due to dieselization of the railways and the inroads of natural gas and oil into the domestic market. A slump in the coal industry followed these changes and production did not pick up until the latter half of the 1960's when large off-shore markets were obtained (Fig.3). The prime market to date is the Japanese steel industry where competition with U.S., Australian and other coal has been fierce. The obtaining of the contracts with Japan has been widely credited to the lowering of the over-land transportation cost due to better (unit) train economies. Potential markets in various parts of the U.S. and Canada are also undeniably becoming more important.

Sulfur.--

While coal has been produced in the west almost since the beginning of its settlement, sulfur is a latecomer which actually came about incidentally in the beginning of the 1950's. With the production of natural gas it was found that, depending on the well site, hydrogen sulfide

TABLE III. WESTERN CANADIAN COAL TYPES AND PARTICULARS

(Refer to Fig. 2)

Sources: A.S.T.M., Research Council of Alberta, Canadian Mining Journal

No.	Fig. 2 Code	Designation	Principal Areas in the West Commercial Importance	Heat Value B.t.u./lb.	Per Cent Volatile Matter	Storage Properties	Main Uses	Caking Qualities
1	ma	Meta-anthracite	Not occurring					
2	an	Anthracite	Not occurring					
3	sa	Semi-anthracite	Canmore area	N/A	8-14	Weather resistant; Can store in the open	Domestic Heating; Blending with caking varieties	Non-caking
4	lvb	Low Volatile Bituminous	Canmore, Crows Nest, Smoky River, Luscar	N/A	14-22	same	Metallurgical Coke	Caking
5	mvb	Medium Volatile Bituminous	Crows Nest, Luscar, Chetwynd, Telkwa	N/A	22-31	same	Metallurgical and other coke	Caking
6	hvAb	High Volatile A Bituminous	same	Greater than 14,000	Greater than 31	same	Metallurgical and other coke; also for blending	Caking
7	hvBb	High Volatile B Bituminous	same	13,000-14,000	N/A	same	same	Caking
8	hvCb	High Volatile C Bituminous	Coalspur, Lethbridge, Prairie Creek, Saunders	10,500-13,000	N/A	same	Steam raising	Mostly caking
9	subA	Subbituminous A	Princeton, Alberta Prairies, Drumheller, Wabamun	10,500-11,500	N/A	Store under cover	same	Non-caking
10	subB	Subbituminous B	same	9,500-10,500	N/A	same	same	Non-caking
11	subC	Subbituminous C	same	8,300-9,500	N/A	same	same	Non-caking
12	ligA	Lignite A	Estevan area, Turtle Mountain, Princeton	6,300-8,300	N/A	same	same	Non-caking
13	ligB	Lignite B	same	Up to 6,300	N/A	same	same	Non-caking

Note: 1. Caking is the tendency of coal to agglomerate into hard cohesive lumps during the coking process.

2. High B.t.u. coals are classified officially on basis of Fixed Carbon or Volatile Matter (Complementary). In both cases the coal analyzed is to be free from moisture and ash. B.t.u. values are based on coals free from surface moisture and ash.

FIG. 3 CANADIAN COAL PRODUCTION & TRADE

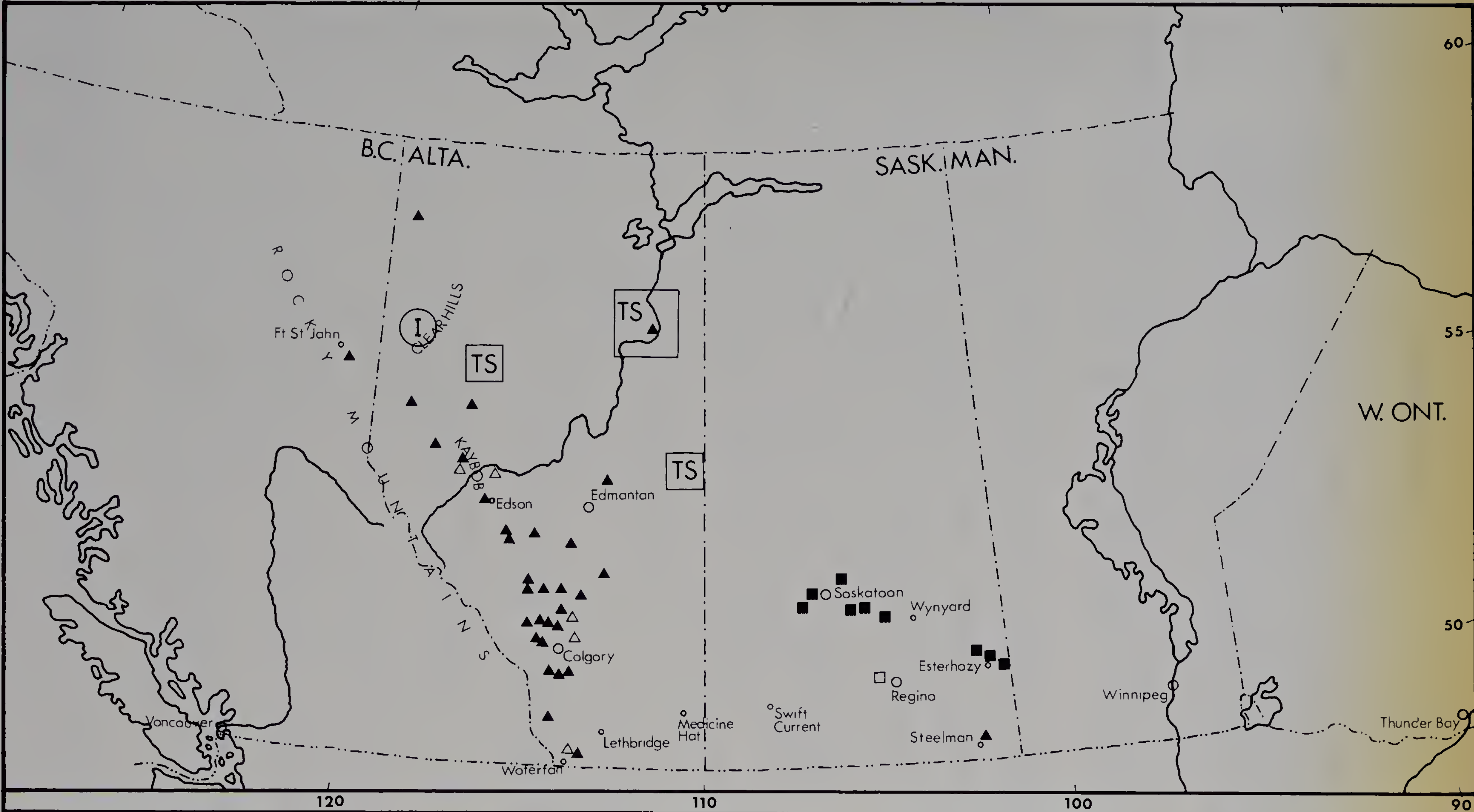
(1) Imports
(2) Exports
(3) Total Production (Including Eastern Canada)
(4) Alta. Prod.
(5) Sask. Prod.
(6) B.C. Prod.

(H_2S) content of the gas ranged from less than one percent to almost ninety percent. The poisonous and corrosive nature of the H_2S made it imperative to remove it before pipelining the remainder of the gas. Sulfur therefore became a major and involuntary by-product of most gas processing plants, and the west, particularly Alberta (Map 7) became a significant producer for the world sulfur market. The production of this elemental form of sulfur (Fig. 4) is in the shape of lumps or flakes of pure material, contrary to the pyritic sulfur and sulfuric acid produced elsewhere in the country.

The uses of sulfur are many, for example acid batteries, plastics, paints, rubber, chemicals and fertilizers, and, probably in the near future, road pavement. Production and tonnage prices have fluctuated wildly during recent years from $30.84 per short ton f.o.b. plant in Alberta during 1968 to $6.45 in 1971. Obviously efficient transportation at low cost is a very important factor in keeping prairie sulfur competitive on world markets.

Potash.--

Potash production is the youngest of the three mineral industries mentioned here, dating only from the early 1960's. Any potassium salt, whatever its chemical composition (chloride, sulfate or carbonate) is denoted commercially



MAP 7 SELECTED BULK MINERALS IN WESTERN CANADA

Sulfur Processing Plant:
▲ Major Producers
△ Largest Producers & Unit Train Loading Points

Potash Mines:
■ Shaft
□ Solution

(I) Iron Ore
TS Main Tar Sands Areas

O o Towns

Expanded Legend on Following Page.

SCALE: 0 50 100 200 300 miles

Legend Map 7

Sources: Energy Resources Conservation Board, Research Council of Alberta, Canadian Mining Journal, Alberta Bureau of Statistics, British Columbia Department of Mines and Petroleum Resources, Saskatchewan Department of Mineral Resources.

Location of Major Sulfur Producing Natural Gas Processing Plants Featured on the Map (Figures Refer to Figures on Map):

Alberta

Shell Canada Ltd. Jumping Pound, Burnt Timber, Innisfail, Simonette, Waterton.
Gulf Oil Canada Ltd.: Turner Valley, Pincher Creek, Homeglen-Rimbey, Nevis, Strachan.
Great Canadian Oil Sands Ltd.: Athabasca Tar Sands.
Atlantic Richfield Company: Gold Creek
Hudson's Bay Oil and Gas Company Ltd.: Brazeau River, Caroline, Edson, BHL Kaybob South, Plant 2 Kaybob South
Lone Pine Creek, Sturgeon Lake South, Sylvan Lake.
Texas Gulf Sulfur Company: Okotoks, Windfall.
Amoco Canada Petroleum Company Ltd.: Bigstone, Crossfield East.
Canadian Fina Oil Ltd.: Wildcat Hills.
Banff Oil Ltd.: Rainbow.
Amerada Hess Corporation: Olds
Home Oil Company Ltd.: Carstairs
Petrogas Processing Ltd. (Jefferson Lake Petrochemicals): Crossfield.
Imperial Oil Limited: Redwater, Quirk Creek.
Canadian Delhi Oil Ltd.: Minnehik - Buck Lake
Chevron Standard Ltd.: Nevis.
Canadian Superior (Leduc) Oil Ltd.: Harmattan-Elkton, Lone Pine Creek.
Jefferson Lake Petrochemicals of Canada Ltd.: Savanna Creek
Tenneco Oil and Minerals Ltd.: Nordegg River (Brazeau River)
Mobil Oil Canada Ltd.: Wimborne.

Note: Beside the 35 plants mentioned above about 10 minor plants (not identified on the map) have recently started operations.

British Columbia

Jefferson Lake Petrochemicals of Canada Ltd.: Taylor Flats (Ft. St. John)

Saskatchewan:
Steelman Gas: Steelman.

Location of Potash Producers in Saskatchewan (shaft mines unless indicated):

Duval Corporation of Canada: Saskatoon.
Potash Company of America: Patience Lake
Allan Potash Mines: Patience Lake
Noranda Mines Ltd.: Patience Lake
Alwinsal Potash of Canada Ltd.: Guernsey.
International Minerals & Chemical (Canada) Ltd.: Esterhazy (2 mines and refineries).
Sylvite of Canada Ltd.: Rocanville.
Kalium Chemicals Ltd.: Belle Plaine (solution mine).
Cominco (Potash Division): Delisle.

Note: A few more (shaft) mines are under construction between Saskatoon and Wynyard.

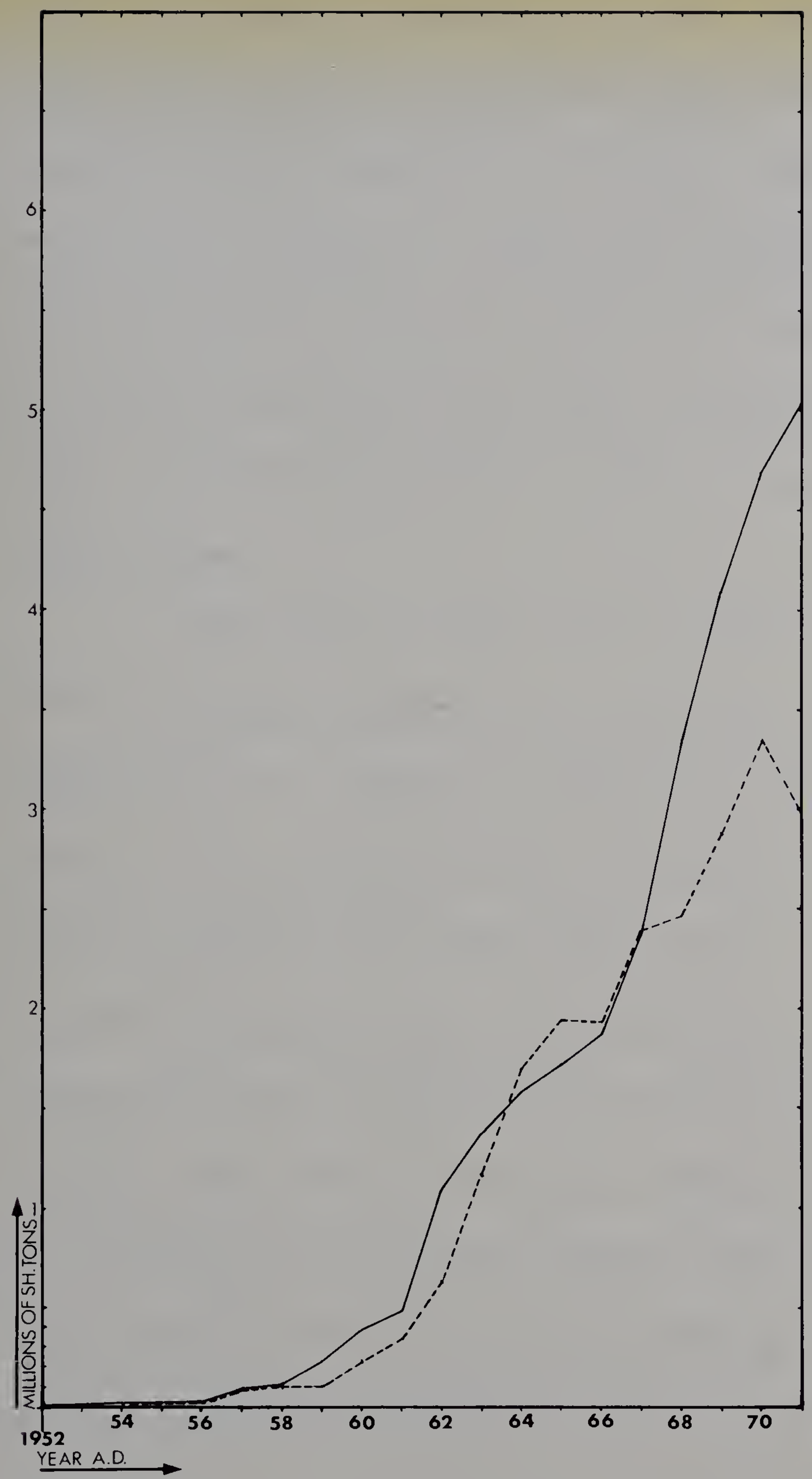


FIG. 4 ALBERTA SULFUR PRODUCTION & SALES

——— Production
– – – – Sales

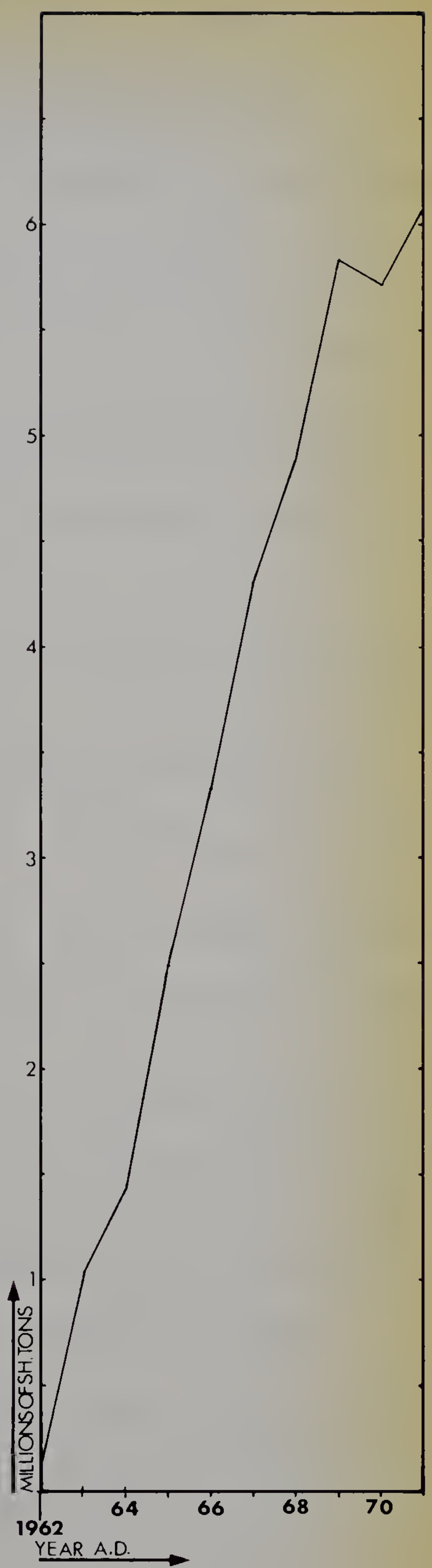


FIG. 5 SASKATCHEWAN POTASH PRODUCTION

as potash. The area in the prairies where these salts are found is large and covers all three provinces. However, the only deposits of economic importance under present conditions of technology and pricing are located in Saskatchewan where a number of mines are in operation (Map 7). Potash production (Fig. 5), carefully controlled by the Saskatchewan government in order to prevent flooding the market, is frequently given in tons of K_2O equivalent (potassium oxide).

The oxide is the form in terms of which the analysis of the mineral is performed and forms a common basis for reporting on a number of different salts. However, all the data in this study have been converted to actual tons moved, that is short tons of KCl (Potassium chloride) which accounts for approximately ninety-six percent of production. Some of the production is utilized as fertilizer in Canada but a much larger share goes to the U.S. Another significant portion is shipped outside North America and can compete on the world market due to improved economies of scale in the field of transportation which gave lower cost per unit.

Movement.--

The movement of the above three minerals in western Canada has been almost entirely by rail, and via relatively few outlets. In the case of coal, production for home con-

sumption did not usually have to travel far, but exports however small they may have been at times, had to be funneled through the port of Vancouver. Prairie sulfur, to reach world markets, also had to pass through the same port as did that part of the Saskatchewan potash which was destined for Japan, Britain and other off-shore markets. Much of the potash production, however, entered the United States via the railroads, some of it after having been trucked south from Esterhazy to the border town of Northgate.

Indications of the problems accompanying the mass shipments via "bottlenecks" such as Vancouver are many. As an example the opinion of J. C. Williams, the Director of Research and Development of the Canadian Pacific can be cited[18]. That opinion has been confirmed by many others. Williams described the situation in the Vancouver port area where, at any one time during the early 1960's, between 900 and 1000 cars, loaded with coal, would be parked in the yards awaiting the arrival of the proper ships. These trains would be reshuffled in the yards according to the incoming news regarding the arrival time of the various freighters. The tie-up could become extremely complex, trains would be in each other's way, and the first ship to arrive might be the last to leave. Meanwhile the rail-

road provided storage for coal in its cars. Similarly, sulfur transport in 1962 required a turnaround time for a car of forty-three days on the average, with waiting time at either end of the run ranging from ten to twenty days.

At this time in the early sixties a car would represent approximately a $10,000 investment and the interest, while waiting, would already amount to about $90.00 according to Williams. These costs had to be passed on to the shippers and consumers sooner or later but were, in fact, frequently losses for the railroad, since waiting periods would vary widely and costs (demurrage) were incurred before being eventually worked into the tariffs.

Williams states that waiting cars could number up to 1500, whereas, if surge storage were available at both ends of the run, a total of one sixth that number would be required, a sizeable saving in capital investment amounting to many millions of dollars. However, the situation had grown historically as a result of non-simultaneous expansion of products and transportation modes. The idea of having the railroads provide these services also developed since they were considered to owe a large debt to the country at large, a notion which was at the bottom of much tariff legislation.

At the root of the railroads' problems was the gradually developed yard system whereby trains were assembled

at a few locations. These trains run between yards for certain lengths of time and then spend several times that period in the receiving, classification and departure yards, undergoing all the attendant switching, back-hauling and waiting. This situation was considered normal and it seemed that little could be done to improve it because, although blocks of cars filled with bulk commodities might arrive all at once, the cars would still have to wait until there were enough of them to make up a train for the same general destination. In other cases the waiting might be for suitable motive power. Within the existing system, however, everything appeared in general to run smoothly and modern technology has undeniably helped to reduce any possible delays to a minimum.

Because of the new technology the following description of a yard system at a general freight terminal may not seem ordinary; however, the basic operations have not been changed[19].

Receiving Yard: Well in advance of a train's arrival all consist data (identity of train, individual cars, destination codes, and similar information) are wired to the terminal and entered into a computer system. The result is a set of information concerning such features as group identities and sizes. Via remote control television,cars'

initials and numbers are recorded on videotape and entered again into the computer for a double check; corrections against advance information are automatically made. According to their destination codes, cars are then assigned to classification tracks. Upon actual arrival of the train the computer locks in a route by setting the switches, it records the arrival time and it indicates the beginning and completion of brake bleeding and inspection (pushbutton initiated from the track).

Classification Yard: When all operations are finalized the yardmaster initiates the humping of the train and the computer lines up the direction of the hump which takes place on a custom designed hill, from which the cars, by gravity, run along previously assigned tracks. Any stops during the process, as well as the reasons are recorded. The computer is informed via the teletyper of the exact location of the cars and is therefore aware of any misroutings. The entire procedure is then logged automatically, displaying all vital data and possible errors.

Departure Yard: After classification the cars are moved to the departure yard by switch engines, while simultaneously computer entries are made concerning all the final data about all cars in the new trains; yard inventories are adjusted automatically. When the train actually departs all

consist information is consequently wired to the next terminal where the entire procedure is repeated.

The major difference between the system used in the vast majority of terminals and the one just described (the Penn Central Perlman Yard) is the degree and extent of automation and computerization. As was mentioned before, with conventional methods the handling of the trains remains the same, but the process is less streamlined and more prone to human error. Loading and unloading, carried out at the stage of the classification yard, can be automated and computerized as well, but the process is bound to cause congestion on the usually scarce numbers of available track.

Complicating and adding to the lengthy procedure of putting a train through is the variety of cars used: different ages, models and the various uses of even one single car. Although cars may be designed for multiple use, the conventional rolling stock is not, and the same unit may be used for instance for potash, grain or phosphate rock, or another unit used for coal as well as sulfur. Slow-downs occur then, not only due to storage in rolling stock, but also due to different handling characteristics of the commodities and the cleaning procedures which have to be rather thorough.

The lack of double track on many busy lines, for

instance in the lower British Columbia mainland, constitutes one more problem. Central traffic control systems were introduced during the sixties to alleviate the problems caused by off-schedule trains and, according to at least one CN spokesman, can increase the effective capacity of a line by approximately seventy percent on most main lines. This development came at a time when it was increasingly recognized that within the near future the railroads would be forced to find ways and means to cope with the problems of ever increasing loads and stiffer competition from other modes. At this time also, at least in western Canada, the railways began to develop and apply the concept of unitized railroading. An interesting note at this point is that essentially a very similar system, but without the name "unitized" attached, was in operation for a few years at the end of, and after the first World War when the U.S. government requisitioned trains for its own purposes. These trains were run successfully by the companies themselves but appear to have been discontinued because they did not fit with the railroad thinking at that time on the part of managerial and regulatory bodies[20].

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CHAPTER III

IMPETUS FOR THE USE OF UNITIZED SYSTEM RAILROADING

As was mentioned in the previous chapter coal has been produced in the west for almost as long as this part of the country has been settled by the white man. Production has had its ups and downs but suffered a serious depression following locomotive dieselization in the 1950's. Although the producers of the sub-bituminous and lignitic coal, found on the prairies (Map 6; Fig. 2), did not suffer quite to the same extent as did the (primarily) Albertan bituminous coal producers, the impact on the industry as a whole was almost crippling, with many small operators being forced out of production. While the production of lower ranked coals (according to calorific value) slowly increased depending on the demand of the thermal power industry, the opportunity for greatly increased production came during a period in the mid-sixties, when a combined effort by the Federal Government and the Coal Operators Association obtained initial contracts for large amounts of bituminous coal for the Japanese steel industry, as well as some anthracitic coal for blending purposes[1].

The Japanese steel industry had been augmenting its domestic coal supplies over the years with imports from primarily the U.S., the U.S.S.R. and Australia, as well as from some smaller suppliers[2]. Being apprehensive about their U.S. supplies in the light of growing American fuel demand, and unwilling to become too dependent on the two next largest sources, the offer of Canadian coal was welcomed with a certain degree of enthusiasm. The conditions on which the deal would hinge were basic: adequate quality of coal, reliable source and production, reliable and steady delivery, and a competitive price.

The coal of the Rocky Mountain inner foothills was found to be of good metallurgical coking quality, low in moisture, ash and sulfur, and well suited for blending with the Japanese coal as well as with the Australian imports in the Japanese coking ovens. The reliability of production was not considered a problem in the light of the Canadian political and labor scene. However, the undependable nature of the transportation system in Canada was regarded as a major obstacle. The representatives of the steel consortium in Japan were familiar with the many problems of the railroads, such as bad winter conditions, bottlenecks in the largely single track railnet, lack of cars at critical times and multiplicity of car use. If these difficulties could be

eliminated large contracts for coal could be signed.

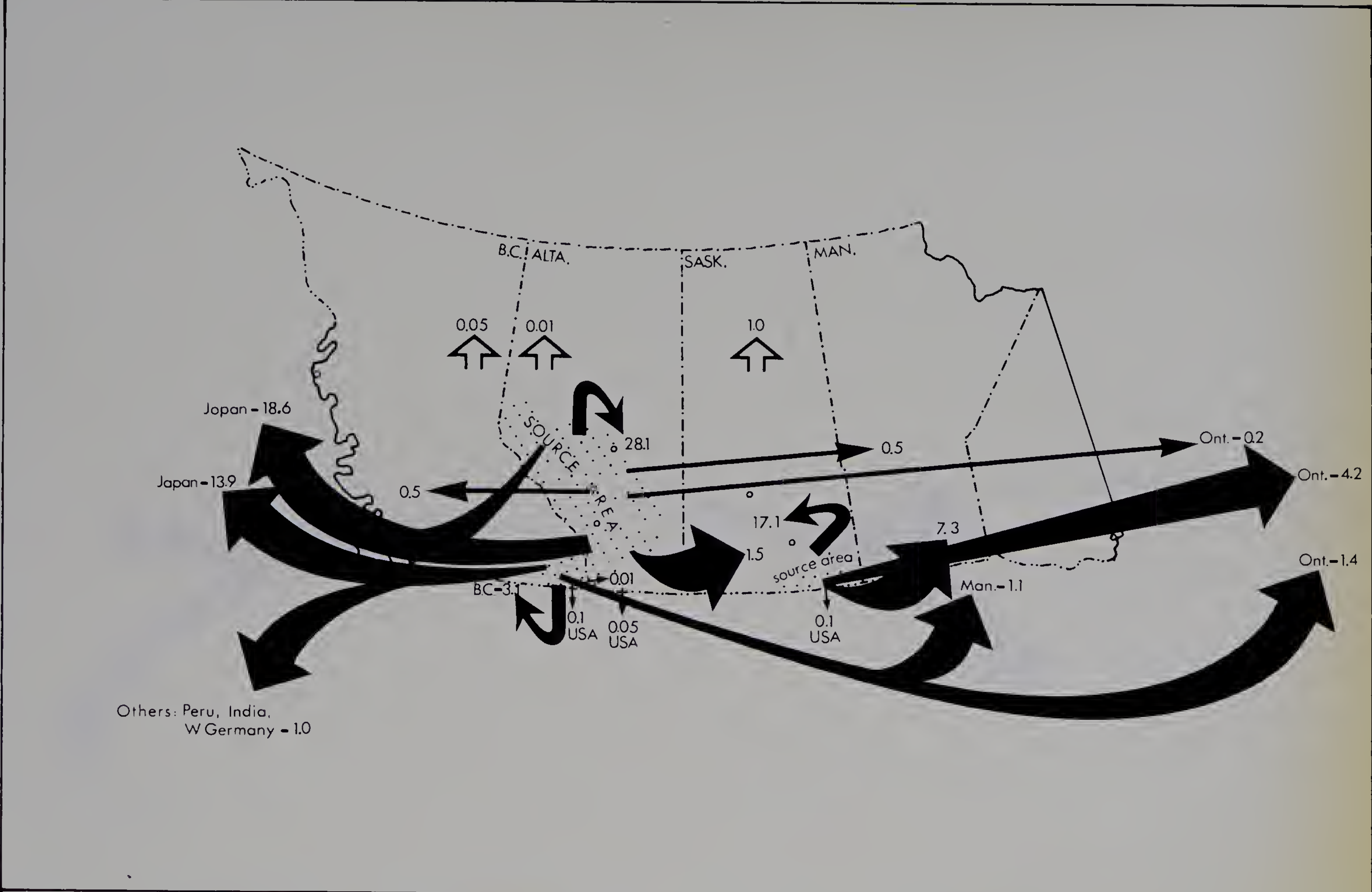
Other pressure on the western mines is coming from western and central Europe, where coal production is diminishing and demand for imports is increasing. Then there is the possibility of markets in the western United States[3]. Another, not too distant future market appears to be in the Canadian steel industry in Ontario, which may experience instability of coal supply from the U.S., even for those companies with their own mines, such as Stelco. The potential for coal sales in all of these major market areas requires proper transportation facilities since, traditionally, cost of transportation has restricted the movement of western coal.

It was under these conditions that the railroad companies put forward the system of "unit trains", enabling the Japanese contracts to be signed because of drastically reduced transportation costs. Thus the western Canadian product became able to compete in price with the production in foreign, more advantageously located source areas. The projection of costs over lengthy periods was also possible and, therefore, contracts over long terms could be negotiated.

Although the movement of coal was the first and apparently the strongest reason for the introduction of

unitized railroading in western Canada, there are others as well, among which Alberta sulfur and Saskatchewan potash. As can be seen in Fig. 4 and Fig. 5, the production of these two materials has increased by leaps and bounds, according to data provided by Statistics Canada, the Department of Energy, Mines and Resources, the Alberta Energy Resources Conservation Board and the provincial departments concerned with the mining industry.

The slump in the world markets for sulfur and potash during the 1960's was caused by considerable over-production to which western Canada was an important contributor with its sudden high output. In order to retain a significant share of the market lower delivered cost became a necessity and transportation innovation a high priority item in the west. It was largely due to the introduction of unitized railroading that the flow of western production could take place in the manner depicted in Maps 8 (coal), 9 (sulfur) and 10 (potash). The lag between the sulfur production and sales (Fig.4) would undoubtedly be much greater than it is at present if conventional, haphazard carload shipments would have been retained. For potash production the Saskatchewan government has instituted a prorationing system similar to Alberta's oil and gas schemes, which allows plants to operate at a predetermined rate starting in 1969.



MAP 8 – MOVEMENT OF COAL SOLD IN 1970

Flows over 100 000 sh.t.

Production Area

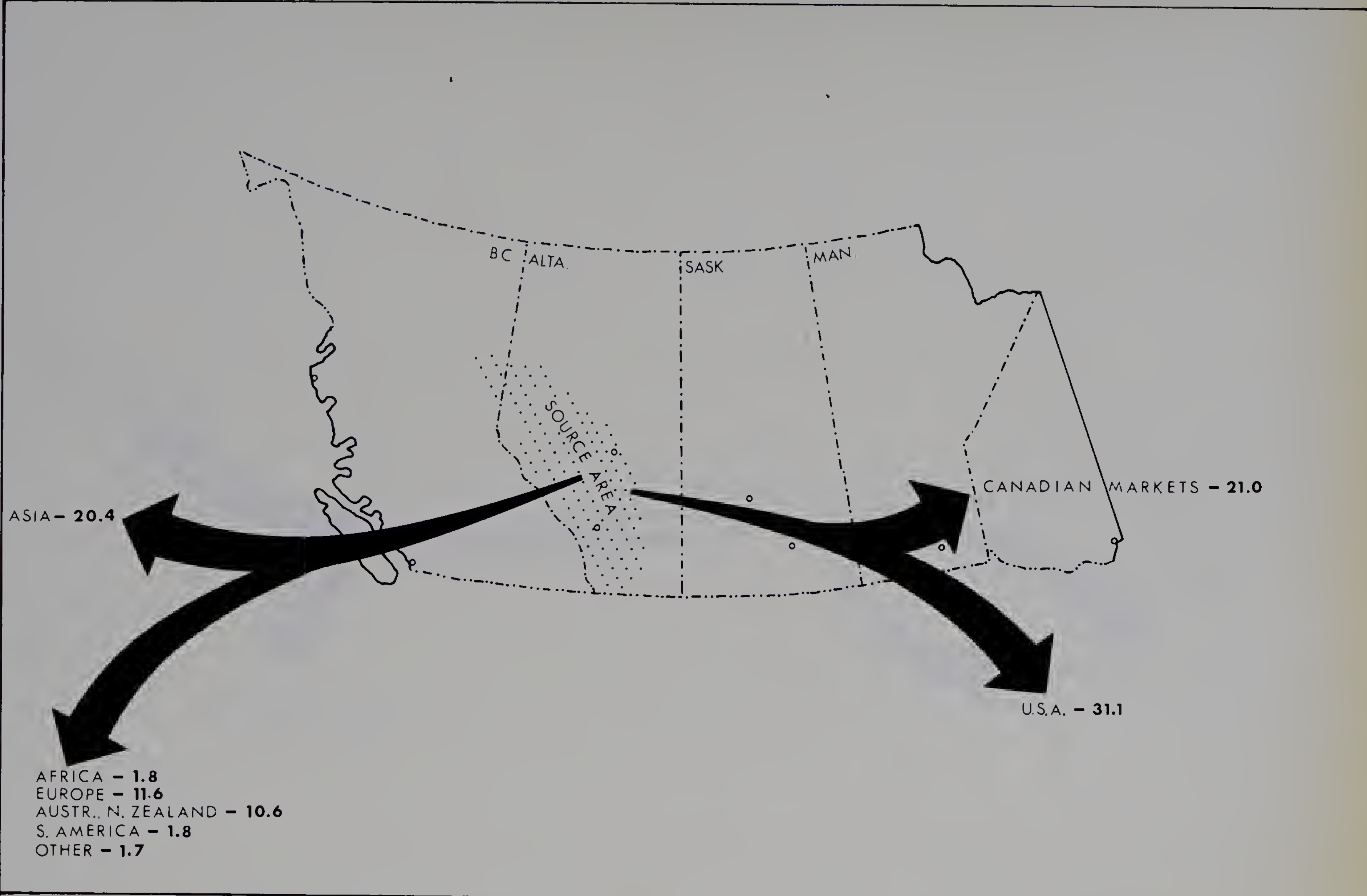
Flows under 12 000 sh.t

Flows between 12 000 – 100 000 sh.t.

Sales to railroads

Internal Provincial flows

The figures give percentages of total of shipped coal. Arrows lead from source to market. Markets are named only when arrows terminate outside provincial boundaries.

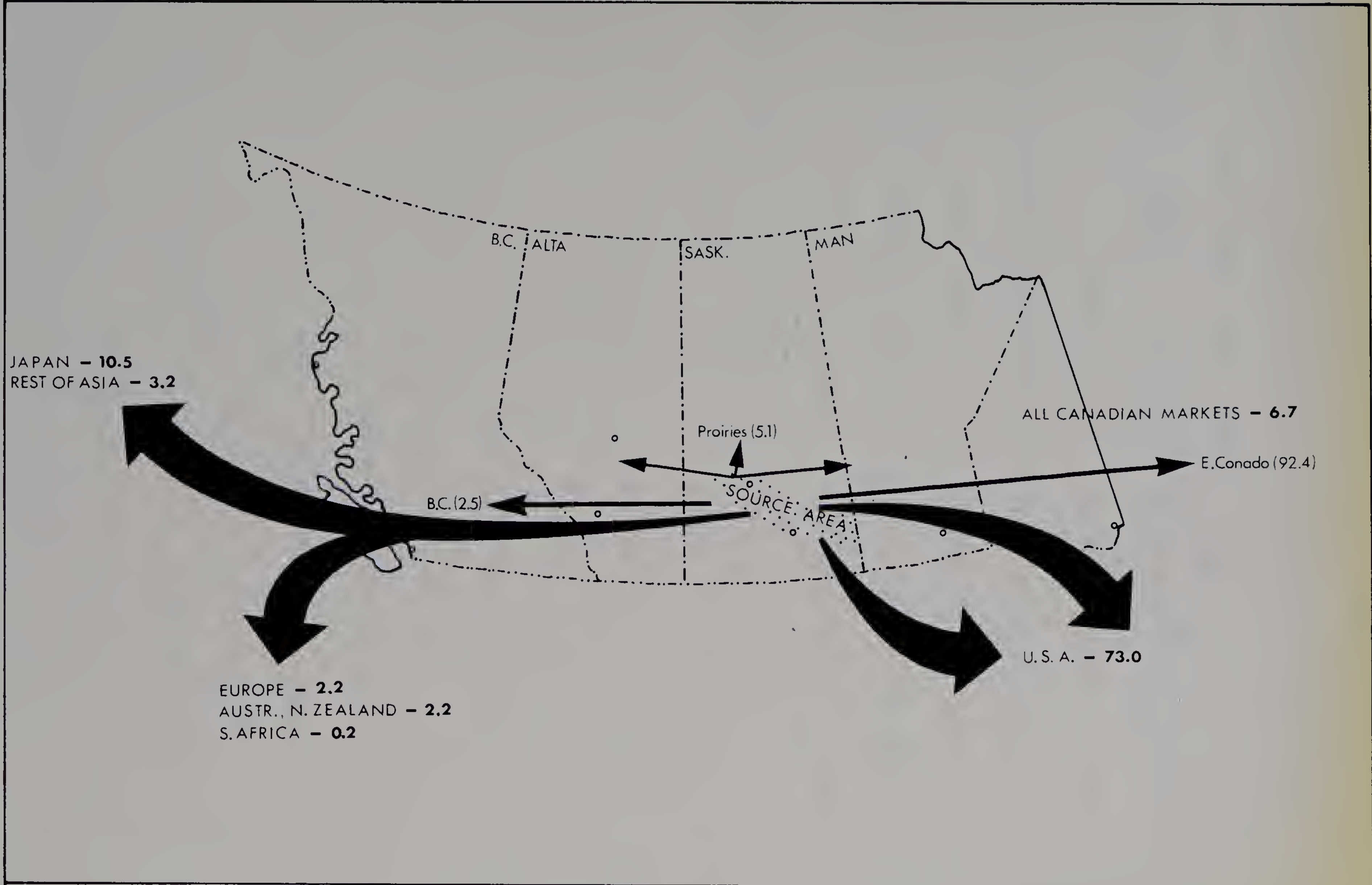


MAP 9 – MOVEMENT OF ELEMENTAL SULFUR SOLD IN 1970

General direction of Sulfur flow

Production Area

Figures indicate percentages of sales moving towards the named markets from the general source area.



MAP 10 – MOVEMENT OF POTASH SOLD IN 1970

General direction of Potosh export flow

Production Area

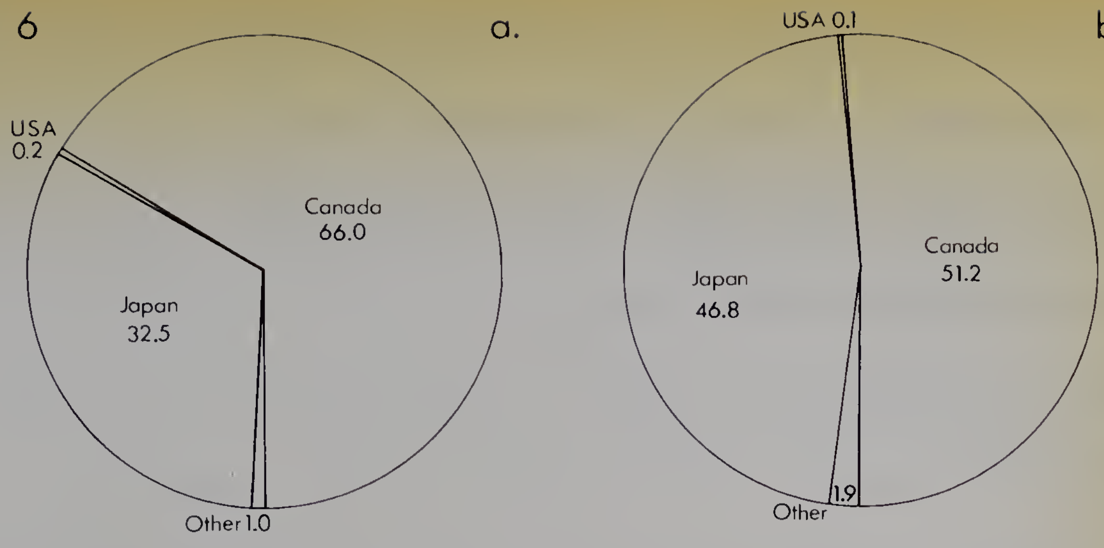
Denotes Patosh flow within Canada

Bold figures indicote percentoges of soles moving towords the named foreign morkets and the tatol notional market from the source oreo. Figures in ( ) are percentages of Conodian soles.

The average figure for potash production during 1970, for example, was approximately forty-five percent of a mine's capacity in order to prevent flooding the market, which would drive the prices down. World market destinations for coal, sulfur and potash sales are represented in Fig. 6, Fig. 7 and Fig. 8. As can be seen from these illustrations efficient long distance transportation is of extreme importance. The Canadian share of the sales for all three commodities will continue to dwindle for many years to come because the home production is constantly outstripping domestic consumption.

Actually meaningful calculations of the capacities of the railroads may be impossible to obtain for the conventional system. Innumerable factors of friction and uncertainty plagued the rail operations and their existence was usually painfully obvious, although the railroad companies felt that they could do little to improve the situation on a piece-meal basis. The problem was too massive in nature due to the fact that it affected all levels of the organization; for example, lines were congested, terminals were slow, and cars were frequently impossible to find for extended periods. Comparisons between traditional and "unitized" railroading lack in value because of such factors. However, the introduction of unit trains has made it possible to moni-

FIG. 6



1970

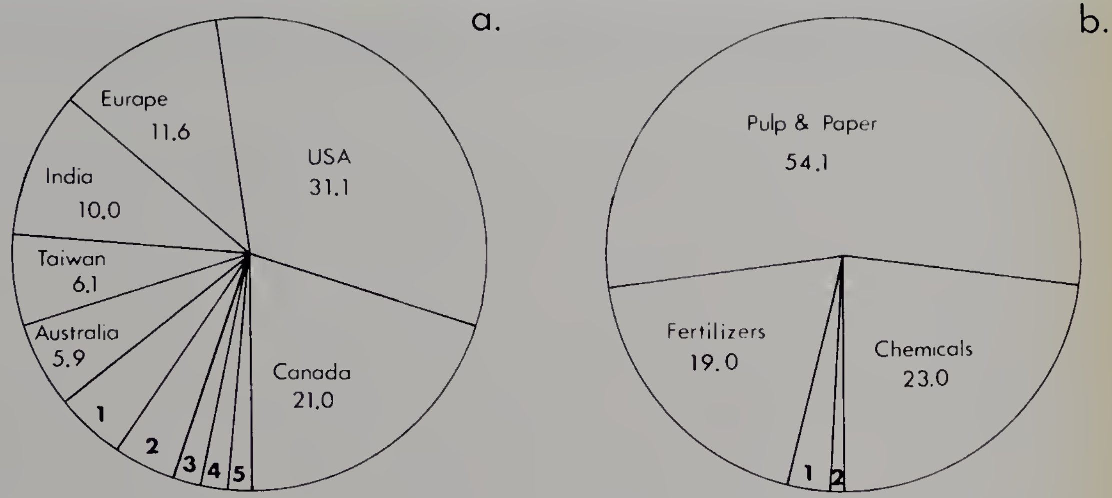
Percentages of the 12,848,461 sh.t. Shipments

1971

Percentages of the 15,809,306 sh.t. Shipments

Destination 1970 (All Markets), Destination 1971 for W. Canadian Coal in Percentages

FIG. 7



1 - N Zealand 4.7
2 - Korea 4.3
3 - Africa 1.8
4 - S.America 1.8
5 - Others 1.7

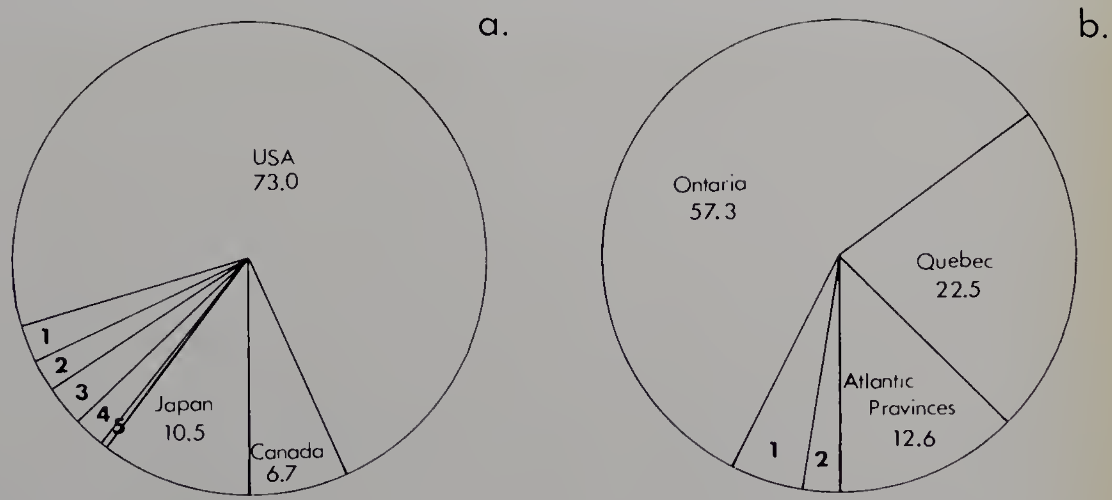
Percentages of the 3.8 Million sh.t. Sale

1 - Other Industries 2.9
2 - Rubber Products & Foundries 1.0

Percentages of the 0.8 Million sh.t Domestic Sale

Destination 1970 for W.Canadian Sulfur (%) - Canadian Use of Western Sulfur in 1969

FIG. 8



1 - India 2.4
2 - Europe 2.2
3 - Rest of Asia 2.8
4 - Australia & N.Zealand 2.2
5 - S.Africa 0.2

Percentages of the 5,602,367 sh.t KCl Sale

1 - Prairie Provinces 5.1
2 - British Columbia 2.5

Percentages of the 379,678 sh.t. Domestic Sale of KCl

Destination 1970 (Foreign and Domestic) for W. Canadian Potash in Percentages

tor and control of all facets of a transport operation to a much greater extent. Another problem in comparing the "old" and the "new" is the fact that most unit trains, especially in western Canada, are performing services which did not exist as such previous to their introduction; some exceptions are dealt with in Chapter VI. It was discovered that rates which were already considered barely compensatory, or sometimes inadequate, could be lowered even more, while reliability and apparent capacity could be raised.

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CHAPTER IV

INTEGRAL AND UNIT TRAIN SYSTEMS

I. CONCEPTS AND THEORY OF OPERATION

As MacAvoy and Sloss[1] flatly state: "The terms "unit train" and "integral train" are frequently if incor- rectly - used interchangeably." Apparently the statement made in 1967, still holds true, as was borne out during the questionning of a few railroad officials approximately six years later and by the interchangeable use of the terms in the literature.

In 1963 Gellman used the term "unit train" to de- scribe an innovation which was managerial and not techno- logical in nature. He used the term "integral train" to define a technological and managerial innovation[2]. The author of the only published in-depth study of integral train systems, Kneiling, ostentatiously agrees with this view when he describes unit trains "and other supervised services" as mere "conceptual intermediates"[3]. Although the technology for the integral train has been in existence for many years, and management changes could have been

introduced long ago as well, it is the new, actual application of the available techniques which has led to this innovation which some have called the greatest since dieselization.

The best definition of an integral train found has been that presented by Kneiling[4]: An integral train is a whole train existing as a fixed consist, that is, as a whole, inseparable unit, including its power, specialized or not, and handled as a unit independently of general purpose equipment and other railroad sub-systems. It operates in a system which contains the train (and its spare elements), the terminals and the service accessories it requires to perform transportation. It is run only for maximum efficiency and is considered to be in motion in its normal state, contrary to conventional trains which are considered stationary in their normal state (Fig. 9).

Realizing that some factors in the design environment may not allow for an ideal, specific integral train system at a particular time, Kneiling suggests that a transportation plan should therefore include at least those aspects of the integral train which can be incorporated. Obviously such circumstances lead to the design of a system which occupies a place between the integral train system (the ideal) and the conventional methodology. One

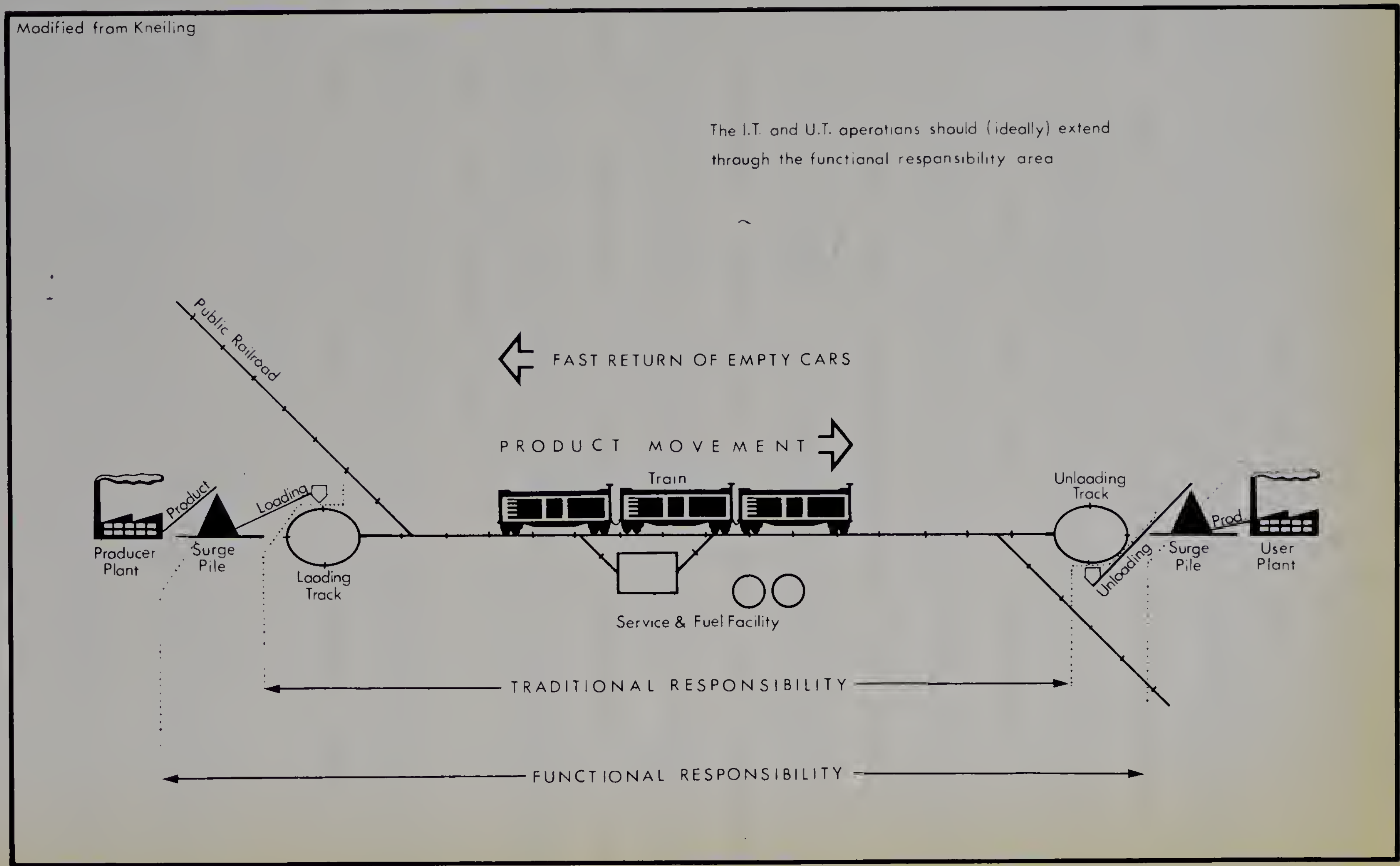

FIG. 9 BASIC INTEGRAL TRAIN SYSTEM

of these intermediates Kneiling defines as follows: "A unit train system is a system whereby more or less conventional cars are moved in a more or less supervised service with the capability and intention that part or all of the equipment be interchangeable with other general-purpose equipment, with or without control of the empty cars once a mission is completed"[5]. This definition leaves the door wide open for a rather wide variety of services to be called unit trains. However, through practical applications it would seem that this terminology would be limited - in general but not always - to the description given by Glover, Hinkle and Riley, who define a unit train as a management technique which permits efficient planning through long-range contractual commitment of producer and consumer and dedication of equipment; the train is to be on a predetermined schedule and in intensive use[6].

Thus listing systems of rail transportation in terms of efficiency, as described in the literature, there are, from least to most efficient:

1. Individual cars } Shipped after gathering in varying train consists.
2. Blocks of individual cars }
3. Individual blocks of cars }
4. Individual blocks of cars moved in trains of similar consist (modular, block and solid trains).
5. Unit trains
6. Integral trains

As will be seen in subsequent sections a number of variables

is possible which, due to lack of further definition, are classified under one of the above types, but require handling methods markedly distinct from one another in certain aspects. It should be noted that the notion that a unit train means that it is running between only two terminating points, as might be understood from some sources[7] is not necessarily true and is not indicated by the definition. As with so many theoretical concepts tested in practice it is often difficult to draw a sharp dividing line between two certain sets of ideas; the problem in this respect is increased considerably when both ideas or systems borrow from each other a number of factors, and when each involves a number of variants. It is consequently held in this study that an integral train system, not present at this time in the Study Area and perhaps unattainable, is the ideal situation which all unit train systems should strive to reach. However, these attempts can only be based on practical circumstances which might dictate a design of more apparent optimum benefit to the parties involved (shipper, carrier, consignee) than the theoretical integral train. Examples of such circumstances would be: large but fluctuating annual shipments, a shift on more or less regular basis of shippers and/or consignees, a gradual build up in annual tonnage to be

shipped, or potential friction between those involved about responsibilities. In the next section a general system of design for unit train operation is given, based on what appears to be commonly utilized in North-America, as well as a number of possible methods of operation.

It was stated previously that the impetus for the use of unitized railroading in western Canada was the sudden, strongly growing demand for efficient and reliable transportation for resource based industries (Ch. 3). However, beside fulfilling this industrial and market need the railroads had a number of problems of their own which caused them to realize that the time was ripe for upgrading of services. It is common knowledge that, since World War II, the share of the railways in the transportation of bulk commodities has been constantly and significantly eroded by other carriers[8]. The decline has been in the percentage share of traffic rather than in terms of actual tonnage moved by the railways. Other carriers have proved more efficient and more adaptable to advances made in the utilization and handling of certain products. Competition between the railways and other carriers has been fierce all across the nation and gains in the share of traffic made by any part of the rail network were regarded as benefiting the system as a whole in

its fight for survival

Concerning the integral train proper, Kneiling reiterates numerous times the need to have the system operate with its own equipment, which should be new and specifically designed, and under its own management, independent but made up from the managements of the involved organizations. He thinks it possible only then to run the system as a separate entity, operated only to make money within its defined limits which encompass loading, carrying, servicing and load-out. As will be obvious at this point, the essence of the new system is to discard as many of the "unnecessary" time consuming manipulations in transport and handling as possible, to reduce or eliminate cost centers[9], and to provide safeguards for the necessary new investments. In the design of a unit train, therefore, as many features of the integral train concept should be incorporated as appears possible, and, except for the separate management which is extremely difficult to achieve, the ideal system is approached in various aspects of a number of operations. As examples could serve the CP Rail system to move coal from the British Columbia Crowsnest area to the west coast, or the CN system to ship iron ore pellets from the Timagami area in Ontario to the Dofasco steel plant at Hamilton.

2. APPROACH AND DESIGN OF AN IDEAL UNIT TRAIN SYSTEM

A producer of bulk commodities, or the consumer of such material, when assessing the need for transport within the framework of his distribution or consumption, has to decide frequently between alternate modes and weigh the long term advantages of each individual carrier. In recent years it has become fashionable to hire outside consultants to carry out such cost-benefit analyses. However, whether that is the case or not, it has proven to be essential to have all interested parties (shippers, carriers, and consumers) pool their information and come to an agreement concerning a reasonable allocation of investments, operating costs and revenues for all the options which exist. This approach avoids the trouble Ruppenthal identifies in planned operations which are not run at optimum levels only because the respective parties were unable to reach agreement in advance[10]. Usually the situation is not as simple and straight forward as Kneiling repeatedly suggests by saying that the system should just be built and run, and that afterward the parties can sit down and divide the revenue on the basis of the capital provided by each. It would be, theoretically, ideal but its implementation is one of the reasons for the problems in establishing a true integral train system.

During the consultation sessions operational aspects of all possible carriers are considered to great extent and worked out into even greater detail when tentative decision is reached. For the case where a unit train system would be seriously considered the following aspects are intensively studied as parts of the system's overall environment and in combination with each other[11]:

A. The economic or market component which deals with a level of cost which can be achieved and with the relationships of these (generally) lower levels of cost and the markets which the train is to serve.

B. Factors relating to the operation of equipment, such as the operation of abnormal tonnages and lengths on rigid schedules and all the accompanying technological design aspects; also included are factors associated with the special terminals through which the equipment must be operated.

C. Regulatory attitudes which include various governmental regulations as well as economic, safety, pollution, political and labor controls to which rail carriers are or may be subjected.

D. Intellectual or managerial attitudes among which the system must be conceived, designed, constructed and operated effectively and economically. This factor

encompasses attitudes of personnel of all parties concerned, labor as well as management, and of all other individuals or groups of people whose livelihood is touched by the new system.

A. The economic component.--

This aspect of the system and its environment is perhaps the most difficult to work out because, beside investments, rates and market supply situations, it deals with monetary costs. It would appear that relationships between rates and costs are extremely variable and that cost figures are in reality unobtainable. In part this is a result of extremely complex costing and accounting systems, although primarily it would seem to be due to the fact that most companies, and especially the rail carriers, are entitled to consider these figures confidential, which they consequently do with extreme care. Requests for any costing information other than that issued via company publications or press releases invariably netted apologies for inconvenience caused by the proprietary nature of this material. These findings are corroborated by the fruitless attempts of some provincial governments during

1973, which were widely publicized via the news media.

The first approach in the detailed look at the situation is concerned with a survey of the product to be shipped to the consumers. Competing sources have to be identified as well as alternate markets and possible substitute materials. Consumption on an annual basis and projections for future requirements, as well as seasonality of production and consumption have to be established at this point in time. Examples of such studies are the combined CN - CP Rail survey of the coal markets in the Great Lakes Area[12] and, somewhat less specifically oriented, the surveys of the Canadian coking coal industry by Wisener and Partners[13]. After having carried out these important preliminary investigations and when a sustainable product output has been determined and a guaranteed minimum consumption has been assured for a minimum number of years the planning group turns its attention to the train system to be used without entering, at this stage, into technical engineering problems.

The train size, its costs, the number of trains are factors closely interwoven with the conditions stated in the previous section and are a natural continuance. Snouffer and Hanson[14] suggest that there are practical limitations which restrict train sizes to the range of

7,000 to 14,000 tons, a fact which seems to be supported by the literature dealing with U.T. operations all over the North American continent. The authors also consider the practical tonnage levels from one source or to one destination to be in the range of 350,000 tons to 7,000,000 tons annually (Table IV). Minimum contract periods were not found in the literature but indications are that the smallest design would require at least an assured life span of 5 years.

Table IV - Typical Ideal Tonnage Levels Based on Real World Situations (Snouffer and Hanson)

		Tons per Year In	
Frequency	Trains per Year	7000 Ton Trains	10,500 Ton Trains
2 Trains per Day	500	3,500,000	5,250,000
1 Train per Day	250	1,750,000	2,625,000
Alternate Days	150	1,050,000	1,575,000
Semi-Weekly	100	700,000	1,050,000
Weekly	50	350,000	525,000

The apparent difference between daily and annual frequencies of trains as indicated in Table IV occurs because of the spare time allowed in the plan for contingency purposes. Although penalty clauses are normally written into the final contracts, a realistic flexibility is applied with regard to the various stages of the producing-moving-consuming process in order to accommodate unforseen problems in operation[15].

The train size to be used is decided upon after considering the available rolling stock and the financial possibilities of designing and building specific equipment. However, the number of cars can vary widely; for example, the first experimental design for an integral train that could be found is the one conceived by the engineering firm of Theodore J. Kauffeld of New York in 1962[16]. Kauffeld's concept envisaged trains approximately three miles long, containing seventy-two cars, twelve interspersed motive units and no caboose. Each car had the length of approximately three standard cars and the train capacity was 37,800 tons of coal. Meanwhile, events show that such designs can be easily superseded: by 1968 the N & W Railroad in the U.S. operated a coal train of 500 standard sized cars (four miles long) from West Virginia to Ohio[17]. Generally speaking, although conditions may dictate or allow a wide variety of lengths, most unit trains services in North America operate trains containing from 30 to 140 cars, with the longer trains generally operating over longer distances. Although shipment of large quantities over long distances (such as 500 miles or more) is commonly considered most economic via the railroad, shipment over short distances may be equally feasible using this mode.

Two examples may be cited: an earth fill dam project in California involving a distance of eighteen miles and four trains of about forty-five cars each[18], and a sand processing plant in New Jersey with a transportation distance of twenty-five miles and a train of ninety cars[19]. The governing rule in such cases is, however, that rolling stock and locomotives are designated to the specific task at hand after train size and the number of trains has been determined.

The type of rolling stock, number of power packages, types and sizes of loading and unloading facilities can only be decided upon after technical research has been carried out and with continuous feedback of information between the various stages of research. The cost of the system components can vary widely but quality of equipment cannot be compromised. The expenditures are balanced against the advantages of the unit train system which, according to Stewart and Kloss, amount to unit trains producing "... a return on investment that is more than double the return on investment in conventional train operations even though unit train revenue per ton mile is typically only fifty percent of the conventional train revenue per ton mile[20]" The authors emphasize some of the efficiencies outlined in Table V. Their findings on the percentage of "time active"

may be slightly more realistic than those of Gunn who estimates the moving percentage as ninety percent of the time[21].

Table V
Typical Patterns of Equipment Utilization
(Stewart and Kloss)

Moving Trains	Conventional Trains	Unit Trains
Percent of time	10	70-80% (+)
Days per year	37	274
Miles per day	52	200-700

Another estimate for equipment usage is given for the previously mentioned earth-fill dam project in California, where rolling stock is estimated to make 1600 trips per year versus eighteen to twenty trips per year for an average railcar. The short distance involved here (eighteen miles) does not alter the fact that the cars would appear to be in almost continuous service, and this calls for quality construction. Investments in equipment and ancillary structures will be dealt with in the next chapter which deals with a specific example of unit train operations.

B. Factors relating to the operation of equipment are crucial if the eventual design is to meet expectations. Sargious points out that "since in most actual projections the projected environment of the system cannot be described with great accuracy, the prediction of the system's response

will be equally imprecise. In all but the most trivial cases it will even be impossible to describe the probability distribution of the response[22]". For this reason it is mandatory to carry out experimental work with real equipment and not to rely on experiences of services in other areas and under different conditions, or on results of simulation experiments.

Choice of rolling stock has to be adapted to the least favorable conditions under which the system is to operate. Car lengths may vary according to curvatures of the roadbed and regulated clearances alongside. However, maximum gross weight on rail for cars with thirty-six inch wheels on two four-wheel trucks is limited in both Canada and the U.S. to 263,000 pounds[23]. Types of cars (hoppers, gondolas, flatcars and others) have to be considered for the particular commodity dealt with, as well as for other bulk goods for which the system, in some cases may be used concurrently with or subsequent to the primary design purpose.

Train composition has to be carefully considered in the light of not exceeding permissible draw-bar pull (force exerted on a draw bar of a car when in motion) for the particular car construction, and locomotive spacing through the train has to be determined for the same reason

as well as for obtaining most efficient pull through the particular sort of terrain to be traversed. If these items are not carefully calculated the train may break on up-hill grades with obvious, disastrous consequences.

Terminals have to be considered from the point of view of higher handling capability than that normally required. The loading and load-out systems have to be in agreement with the type of car ultimately chosen and may vary from standard hopper car facilities with bins, thawing sheds, car shakers and other such equipment, to pressurized systems (such as Flexi-flo, Marcona-flo and Pressure Flow) or rotary dump systems. All terminal systems should have high capacity conveying equipment linked to surge storage.

A final item of consideration in this section is the route which the new train has to use. For the hauling of long trains carrying abnormally heavy loads on a regular basis, usually combined with other traffic, the railroad has to conform to first mainline standards. In order to improve safety and economize on the tracks it is considered necessary to use rail of 132 pounds. At present the companies are moving increasingly toward replacing conventional track (rails of approximately thirty-nine feet length) with continuous, welded rail of lengths close to one quarter

of a mile, especially on grades and in curves. The reduction in maintenance has proved to be phenomenal with the reduction of wear on joints and increased stability of the cars. For the same reason increased use is being made of concrete rather than wooden ties.

The routes to be followed on the basis of available or newly constructed trackage will, according to accumulated information, cause the new train system to operate essentially on the basis of one of the possibilities depicted in Figure 10. For comparison a number of non-unit train operations have been included in the diagrams. The unit train designs contrast with the more conventional types in their handling and equipment dedication. Handling at the terminals is reduced to stopping the trains only for fast loading and unloading or by allowing them to undergo these processes while moving at a very low speed; uncoupling should be considered only if a train cannot be accomodated with a terminal track of a full train length. The modi operandi depicted in Figure 10 are dealt with in the following paragraphs in the order of movement number; the movement diagrams are adapted from Glover, Hinkle and Riley as well as from Kneiling.

The first movements are classified as "non unit

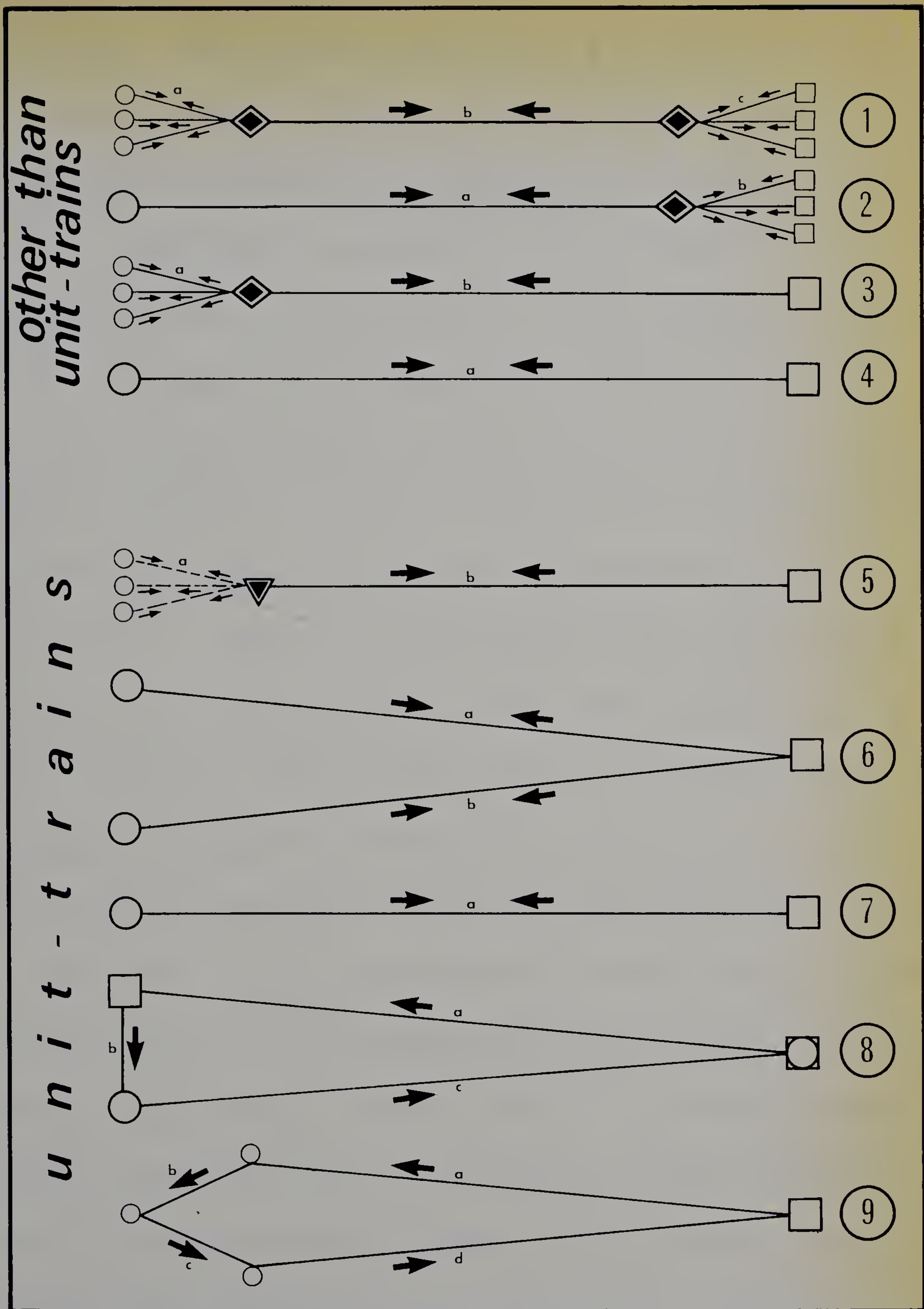

FIG. 10 - Principal Types of Gathering and Distribution

Adapted from Kneiling, Glover

trains" although they may, at first sight, compare with the next five. The proper terminology for these services includes terms such as "modular trains", "block trains" and "solid trains". Unlike unit trains these trains of similar consist, make up or composition may transport the bulk material over long distances, but, depending on the schedules arranged by the railroad on shippers' instructions, trains may be broken up, assembled when loaded and stand idle, waiting for loads. Large yards at originating and terminating points are common, equipment is not dedicated and may be used for other purposes or it may have to be taken from other services. The three names, or variations thereof, for trains in this conventional system are used interchangeably and appear to mean only that a train is loaded essentially with one major commodity.

The unit trains of the five following diagrams have essentially none of the "conventional" draw backs. Movement number five shows a service which is planned between three small producers, the railroad and a large consumer or other receiving terminal. Route leg "b" is for the unit train proper while the short connections "a" lead to the large, high-capacity storage and loading terminal, from which the mixed commodities of all three producers

are transported. It is very similar to movement number seven, except that here the three small producers have been replaced by one large supplier, a so-called shuttle service. Movement number six deals with a situation where a unit train may run alternately between one of a number of sources and a major load-out terminal. The method indicated in this diagram may equally apply to two unit train systems serving one large consumer (radial service). The system represented by movement number eight is different from the previous systems in that there is no shuttle at all. This triangular system is applicable to a situation where a train supplies one commodity to a consumer from a large originating terminal, such as a port, along route leg "a", then travels empty along "b" to a producer and subsequently returns to its originating terminal with a load from the producer along "c". Triangular runs tend to eliminate or reduce costs incurred by empty return trains.

Movement number nine is another example of a unit train serving a number of points. This looped system may combine legs "a" and "d" to a great extent, but essentially would be used where a number of smaller producers, via a common terminal, agree to utilize the unit train system backed by common guarantees of volume. This service, as

indeed all unit train services outlined here, has the in-built flexibility of being used, without compromising schedules and equipment dedication, in combination with other, compatible contracts. However, in such cases this service tends to become a variant of the radial service, or even a tramp system which eventually may mean greatly reduced efficiency due to increased complications. Unforeseen circumstances on other secondarily planned routes can create serious havoc in the situation as originally planned, operated and costed.

C. Regulatory attitudes are extremely important in assessing the limitations within which the unit train system is to operate. These attitudes reflect the feelings and ideas (often pre-conceived) in the environment of the system. The reasons underlying the regulations imposed either by the government or by the railways themselves are rooted in the way people think rail services may affect them positively or negatively. By and large such regulation is dictated by inputs related to economics, safety, pollution control, political considerations and labor agreements. When general attitudes cause certain limitations to be officially established public opinion may change while the resultant regulation will remain for a long time. As an example, one can consider the movement of bulk shipments

in western Canada. Before 1967 bulk shipments were charged on the basis of car loads, that is, rates were proposed by the carriers and applied to the traffic after approval by the Canadian Transport Commission. After this date the National Transportation Act re-introduced initiative into railroad rate making by allowing virtually any tariff rate agreed to by shipper and carrier, including trainloads, provided it were published and compensatory for the costs incurred by the carrier for the service rendered[24], although formal approval remains a requirement.

D. Intellectual and managerial attitudes toward major innovations which directly affect people's working habits, are crucial for the successful implementation of such changes. According to Gellman, change should be looked upon as a blessing and an important resource since, like any other tool of business it allows a firm to distinguish itself from its competitors[25]. Most transport enterprises are slow to recognize change within or outside the enterprise because they do not have an element in their organization designed to identify the changes which are taking place and to recommend courses of action. Only in recent years have some of the largest transportation companies established departments which deal with modifications in designs,

operations, techniques and personnel affairs, usually as an extension to their Research and Development divisions.

The reasons for the slow awakening to change are generally known, but too frequently taken for granted. According to Galbraith, technology not only causes changes it is in itself a response to a change which already has taken place, and resistance to alterations tends to come less frequently from employees without authority than from supervisory and managerial personnel[26]. Nevertheless, Kneiling warns many times that an efficient system cannot be obtained without eliminating the negative attitudes toward improvements of various levels of management and labor. Rather bluntly he points the finger at: people waiting out a pension; persons with vested interests in parts of the operation; staff members who feel associated with a particular aspect of the system or a specific technique, or may be considered as such by others; those who, because of personal insecurities, are convinced that they cannot handle a change; the individuals or groups in the organization who are of the perhaps unfounded opinion that proposed changes automatically reflect negatively upon their own working conditions, incomes and other amenities; and those people who jealously guard their own narrow prero-

gatives. However, beside the negative, emotionally based resistance there is also the negative resistance based purely on apathy and inertia, as well as the resistance based on more soundly deliberated opposition; all of these aspects merit a serious investigation by the company.

Although it is usually more easily said than done, all the "factors of friction" have to be eliminated by careful consideration. The resulting approach ought to be based generally on only a few basic factors: education (good public relations and internal communication), security (assurances against diminishing personal ameneties), participation (such as by teamwork), and a willingness to apply good faith from the side of the system planners as well as from those affected by the changes. The agreements between a number of railway companies and the labor unions with regard to unit train operation may serve as an example. The unions, obviously, were forced to object to reductions of crew sizes inherent in the more streamlined operations. However, in many cases the workers happily accepted the innovation when informed that: a) more trains would be in service, b) crew mileage would be built up much more rapidly, and c) unreliable shift hours could frequently be eliminated.

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CHAPTER V

WESTERN CANADA'S FIRST UNIT TRAIN

1. THE TASK

At the Dominion-Provincial Conference on Coal, held in 1965 in Victoria, the Member of Parliament for Kootenay East, James A. Byrne, referred in his address to the high costs accompanying the mining and marketing of coal and added that, although he was aware of many of the railways' problems in lowering transportation costs, he was convinced that they had ". approached the problem with a lethargy characteristic of the storied Huckleberry Finn". He expressed the hope to hear from them in the near future[1]. At this time the largest export shipments of coal were those of Crowsnest Industries, Ltd., which had contracted, on an annual basis since 1964, for 400,000 tons to be shipped to Japan from the Crows Nest area[2]. During the next few years, however, this company experienced difficulties due to difficult mining conditions. Subsequently, since the coal market for the future began to improve and Crownest Industries could not attract sufficient

Canadian capital for expansion, the Kaiser Steel Corporation was approached and, during 1967, agreed to acquire from Crowsnest Industries, the coal bearing property north of Fernie, B.C. The latter company continued negotiations with the Japanese steel consortium and was assured by them, in January 1968, of a contract for fifteen years to ship 3,360,000 tons of cleaned coal annually[3]. In the following month Kaiser Coal Ltd. (later renamed Kaiser Resources, Ltd.) was formed as a wholly-owned subsidiary of Kaiser Steel, took over the coal property and obtained the contracts with Mitsubishi (Shoji Kaisha) of Japan[4], an importing agent for the steel industry.

Kaiser Resources was well aware of the problems facing it in carrying out the terms of the contract in both the production as well as the transportation of the coal to the westcoast. After setting up headquarters at Sparwood, twenty-two miles north of Fernie and near the mine site, it retained in 1968 Swan Wooster Engineering Company Ltd. of Vancouver for the design of port facilities[5] for Westshore Terminals Ltd., a wholly-owned subsidiary of Kaiser Resources. The terminal port facility was to be built in cooperation with the National Harbours Board and the British Columbia government. Simultaneously Kaiser Resources began dealings with CP Rail in connection with an improved rail-

service which the railway was planning to implement, the unit train, with which Canadian Pacific had begun experimenting successfully since December 1967[6]. In view of the experiences of U.S. railroads and the prospects of western coal on the international market CP Rail had considered it to be wise to prepare itself for unitized railroading.

Thus commenced preparations for the first western unit train. Where Crowsnest Industries could not interest the Canadian investor, Kaiser Steel's financial capability was able to fuse the efforts of producer, carrier and consignee into a truly huge enterprise. Coal of specific quality would be mined in the Crows Nest area and moved, according to predetermined schedule to the harbor from where it was to be loaded with a minimum of time loss into freighters of various sizes which would arrive, again on predetermined schedule, at the port.

2. THE SYSTEM

2-a The Commodity to be shipped.

The coal to be shipped is primarily of the low-volatile bituminous type and its qualities had to be considered by each party concerned from a different point of view. First of all the buyer, the Japanese steel industry, needed coal which could be used for blending

with its domestic supply and, therefore, possessed specified coking qualities. The product had to be a strong coke and for that purpose the ash content had to be as low as possible, the maximum being set at an ash content of 8.75 percent (with a tolerance of 0.5 percent). Sulfur content which, seemingly tends to improve coking qualities somewhat, cannot be allowed to rise too high for reasons of steel making (brittleness of steel) and air pollution. Sulfur content was therefore set at 0.40 percent (with tolerance of 0.5 percent). Volatile matter, a loss in processing, should not vary more than from 19 to 22 percent. All figures are for clean coal and on air-dry-basis[7]. The moisture in the coal should not exceed 6 percent and chunks should be small but carefully sized[8].

Shortly after the signing of the first contract Kaiser Resources obtained a supplemental deal which raised the total tonnage required by the Japanese to 5,600,000 tons per year over a period of fifteen years, that is 84,000,000 short tons over fifteen years to start in 1970. Some allowance was made for the first year in order to allow the plant to come properly on stream.

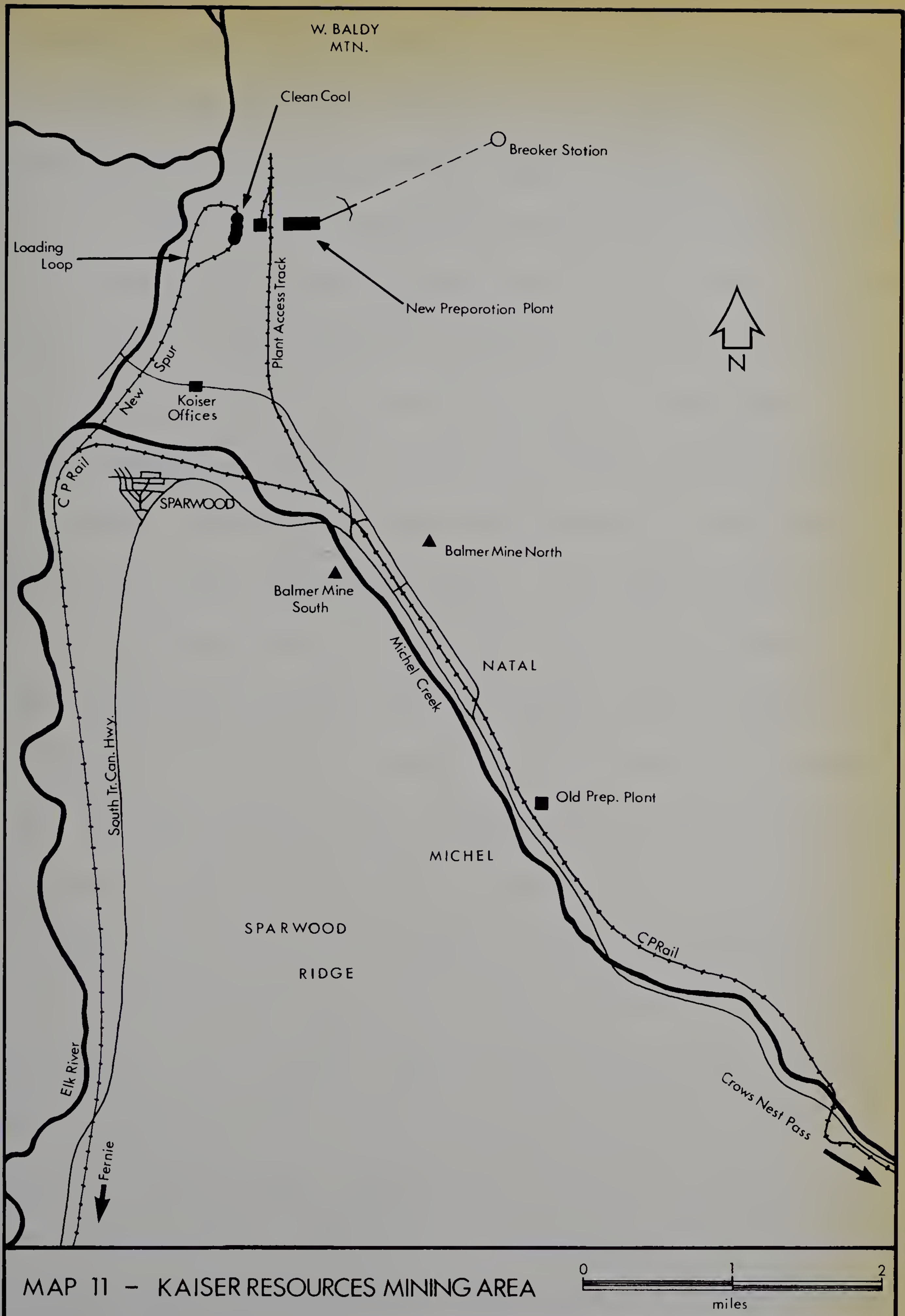
2-b Loading at Sparwood.

The Sparwood area was served by CP Rail but for the new Kaiser venture a spur line had to be constructed to the

area where the cleaned coal would be stored in silos. Rather than utilizing a system, frequently found in many terminals, which would allow the train to move through the loading area and back out, it was decided to use a looped pattern (Map 11). The train passes under the loading hoppers at a steady speed of about fifty feet per minute, under automatic controls in the lead locomotive which compensates for the gradually increasing weight of the train[9]. Manual controls at this time have proven unreliable. Except for the critical speed there are no aspects in the loading procedure which could cause any problems with the train's movement itself. Additionally, sophisticated equipment controls the loading procedure, such as electronic scanners for car numbers, automatic in-motion track scales, and recording equipment which is connected by teletype to rail, mine and port offices[10]. The total loading procedure for approximately one-hundred cars takes four hours (2500 tons per hour). Each of the four load-out silos holds 15,000 tons of clean coal.

2-c The Train

The original train tested by CP Rail contained eighty-eight cars and was designed by the company before the needed number of cars per train was exactly known. Later the actual number of cars varies from 100 to 105 with

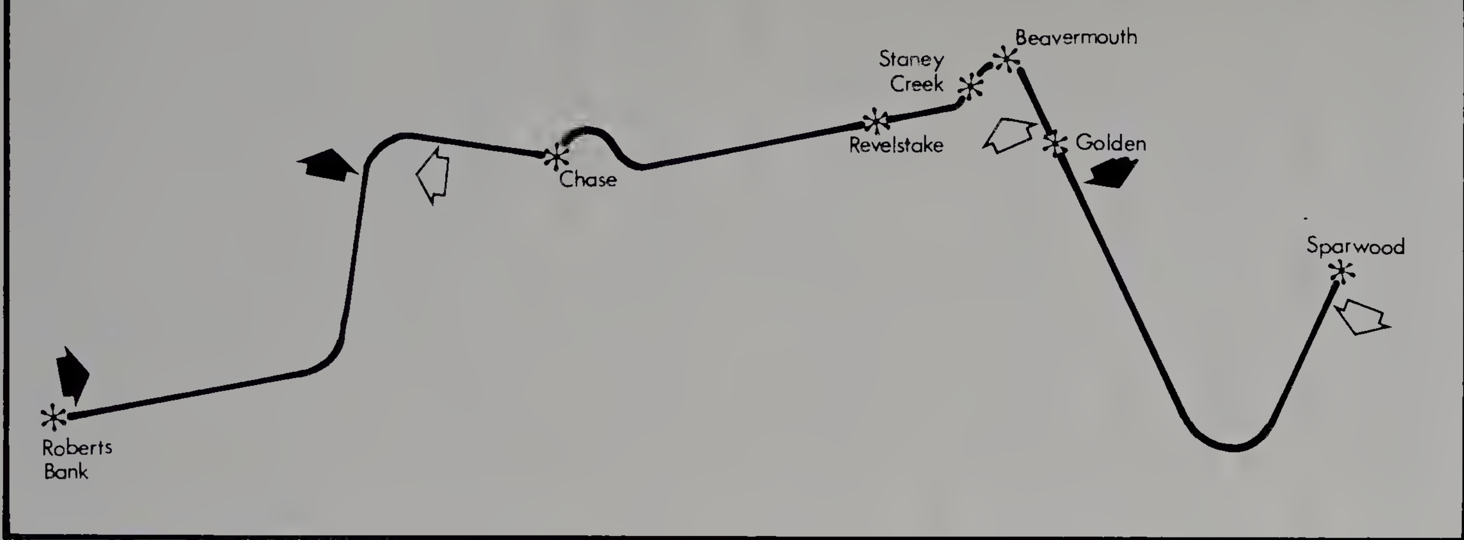


MAP 11 – KAISER RESOURCES MINING AREA

Western Miner

an average of 103 per train[11]. Since the later expansion is based on the original consist design it is appropriate to consider briefly the results of the preliminary work done by the railway as presented to the public[12].

The planned procedure provides for a seventy-two hour round trip between Sparwood and the new port of Roberts Bank (Map 12), approximately twenty miles south of Vancouver, for a total of about 1400 miles. The number of trains scheduled was set at six. A train leaving Sparwood for Golden (223.7 miles) would be powered by four head-end diesels of 3000 horse power each. The eighty-eight car train has these four motive units taken off at Golden since these are the ones with automatic speed controls for the loading procedure. The four units return to Sparwood with an empty set of cars. A new set of diesels takes over, four at the head-end and four "slave units", controlled by a "robot" unit, are spliced about midway in the train. The train is now beginning a slow climb toward Beavermouth, a distance of 27.7 miles. Upon arrival there three pusher locomotives are added at the rear of the train, making a total of eleven power units with a total of 33,000 horsepower which is its peak power. Weighing a total of approximately 14,000 tons the train now starts its steepest climb,



MAP 12
Sparwood - Roberts Bank
Route

Location af Trains at 12:00 Noan in 6 • Train System

Eastbound

Westbaund

CPRail

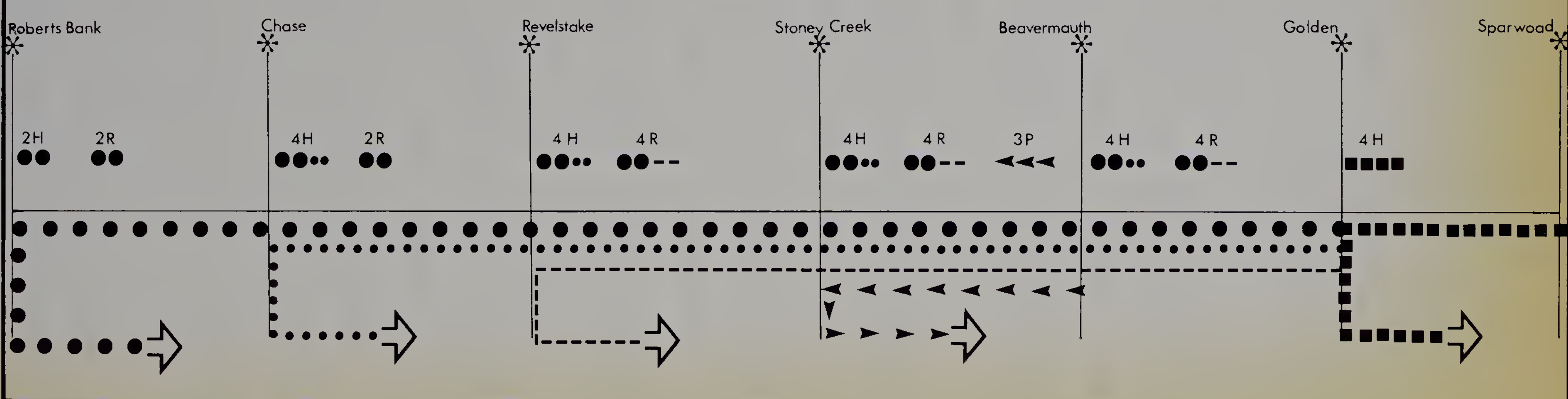


FIG. 11 - CP Rail Motive System
Sparwood - Roberts Bank
Saurce CP Rail

6 • Train System:
Diesels are used accarding ta this schedule for Kaiser and Farding trains between the tawns indicated ✻

H: Head Diesel
R: Robot ,,
P: Pusher ,,

the controlling 2.2 percent grade of the "Beaver Hill" which has its crest near Stoney Creek, a total distance of 14.8 miles. Once over the crest the three "pushers" return to Beavermouth to wait for the next train and the train continues toward Revelstoke (48 miles), where two slave units are uncoupled to help power an empty return train. After another 93.5 miles two head end diesels are removed to power another returning train at Chase, and the fully loaded train continues to Roberts Bank with two head-end and two mid-train slave locomotives (Fig.11).

CP Rail originally attempted the method commonly used in the United States, of using slave units inserted just behind the middle of a train. In this manner the front power units would pull the first half and the slave units the second part of the train. The results were comparable to the situation with all locomotives at the front: coupler knuckles were broken and drawbars pulled out when attempting to climb the steep grades, even though the couplers were designed to withstand 300,000 pounds of strain.

The solution was found when CP engineers positioned the slave diesels at a point in the train where they would push as well as pull. The pulling power of the front locomotives was in this way balanced by the pushing power of the slave units at a point between the two power packages,

that is at the point of "zero draw-bar pull". Since this point (the "node") moves back and forth through the consist during travel the location of the slave units has to be determined in such a manner that the "node" always occurs ahead of them.

It should be noted at this point that a grade of 2.2 percent on mainlines is considered a very heavy grade: 2.2 feet rise in 100 feet distance. According to Hay grades for high-speed and main-line operation should not exceed 0.50 percent, although 1.0 percent is acceptable; grades of 1.0 to 2.0 percent are difficult and normally used only on secondary lines, industrial roads or wherever terrain prohibits anything better - grades over 2.0 percent are very difficult and occur only if absolutely unavoidable[13]. Few grades, he states further, exceed 3 percent. Not only are these percentages critical in climbing, they require powerful counteraction during descent as well since for each percent of grade gravity acts with a force of 20 pounds on each ton of the train[14].

Another problem which CP Rail was forced to overcome was the inefficiency of car design. Standard hopper cars were available which could hold seventy to seventy-eight tons, or traditional flat-bottomed "gondolas", rectangular open-top boxes, which could hold about 75 to

100 tons. The idea of using hopper cars was discarded early, presumably because of inherent difficulties. With non-freeflowing loads problems would occur similar to those encountered in storage bins or silos: "rat-holing" or "bridging", two forms of hanging-up of material being unloaded[15]. At the unloading terminals the cars would be subjected to harsh handling by mechanical car shakers, an act which would be even more difficult during winter time when moisture in the load would be frozen; in such situations terminals frequently install car thawing sheds through which a car moves before being put through the shaker. These circumstances would drastically shorten the life of any car, no matter how well designed. The scale of operations also introduced a cost disadvantage against bottom dump cars. With 300 cars in use,purchase and maintenance costs would balance; however, more than 300 cars were required.

The rejection of the old gondola cars was based on the fact that the empty weight of the car was considered to be too high, 57,000 to 59,000 pounds. The same reason was valid also for existing hopper cars although for them the load-to-tare ratio was even worse due to the heavy doors. According to Williams[16] these ratios fell between 3.2 and and 3.7 to one, which means that cars haul 3.2 to 3.7 tons of payload to one ton of car. The traditional gondolas had,

in addition to not being very large, the disadvantage of relatively weak construction and instability on the rails at higher speeds[17]. As a result of careful engineering CP Rail designed what is commonly called the "bathtub" gondola, remaining within the regulation 263,000 pounds maximum loaded weight. The "bathtub" has a parabolic, selfsupporting bottom, low center of gravity and, due to the use of high strength steel and aluminum, a weight of only 53,000 pounds. It can carry 105 tons at a load-to-tare ratio of four to one and thereby provides one of the best known railcar economies for bulk movement.

The tracks on which the large tonnages of coal will be moved had to be, in part, brought up to first mainline standards. For example, the long Windermere subdivision (170 miles) between Sparwood and Golden contained some thirty-seven miles of eighty-five pound track which initially had to be replaced by hundred pound rail, while curves were smoothed to allow speeds of forty-five miles per hour rather than the customary twenty-five to thirty-five[18]. Later improvements involved bringing all trackage up to 132 pound quality, the common rail for high density lines; other features added to the route were centralized traffic control, a number of new sidings, track extensions and grade improvements, all increasing not only quality

and safety of transport but line capacity as well. Although costs are phenomenal, the railroad expects to be reinbursed by revenues from very large tonnage traffic. Taking CP Rail's own estimate, the track has a capacity for fifteen Crows Nest area coal unit trains with existing facilities but can be expanded to meet any forseeable transportation demand[19]. The company's seriousness on this point might be judged by a 1973 press release which indicated plans to reduce its greater than one percent grades on the route to a maximum of one percent: the "Beaverhill" (presently 2.2 percent), Revelstoke to Clanwilliam (presently 1.6 percent), and a stretch west of Salmon Arm (presently 1.6 percent).

2- d. Unloading at the Coast

Although in conventional rail transport the terminal is no more to the railroad than a number of tracks where freight is loaded and unloaded by the companies it serves, the unit train concept creates a much greater involvement on the part of the carrier. When Kaiser Resources retained the services of Swan Wooster Engineering for the design of a terminal at sea-side CP Rail had a far reaching interest via the principle of maximum utilization of its own equipment.

Kaiser Resources was, in fact from the beginning, in a captive situation with respect to transportation because CP Rail was the only available means of transport. Therefore, when Swan Wooster began searching for an ocean terminal site it was limited to locations which were reasonably within range of the rail carrier, a fact which, fortunately, did not put too severe a restraint on the choice. The first possibility considered was, for obvious reasons, the port of Vancouver. However, the idea of making use of Burrard Inlet for a new, large bulk terminal was not very attractive because of congestion and ship size limitations.

Kaiser had decided to establish its own terminal company rather than making use of some of the large existing ones and the Vancouver harbour was considered to have too many factors against it:

a. Vancouver is the spout of a funnel which handles ninety percent of western Canada's overseas shipments by rail[20]; consequently it is a busy port which is limited in possibilities by reasons of congestion, and by limitations on the physical sizes of the ships to be served there.

b. Vancouver harbour handled in 1965 approximately twenty-three million tons of bulk materials and, was expected

to reach eighty million tons by 1987, without the addition of Crows Nest coal[21]. By then it would have reached the economic limits of development of proper berth sites[22] and no possibilities for adding conceivable pipeline facilities for bulk transport and handling were deemed present[23].

Considering the need for future expansion, the National Harbours Board carried out location studies at the west Coast and determined that the Roberts Bank area, twenty miles south of Vancouver, had the best port potential. The area under control of the Vancouver port authority was expanded from its original forty-nine square miles of water to over 200 square miles, to include the coastal waters south of Vancouver, to the U.S. border and Boundary Bay.

The reasons for the location at Roberts Bank appear to be the following[24]:

a. Minimum low water depths of sixty-five feet, which can be deepened by dredging. This compares favorably with Vancouver's thirty-nine feet.

b. The tidal flat area is ninety square miles. It is the only level coastal area which allows any development of consequence.

c. Relatively direct and uncongested rail and highway

access.

d. Direct vessel access from deep water; largest freighters can enter, while Vancouver's largest is about 100,000 tons.

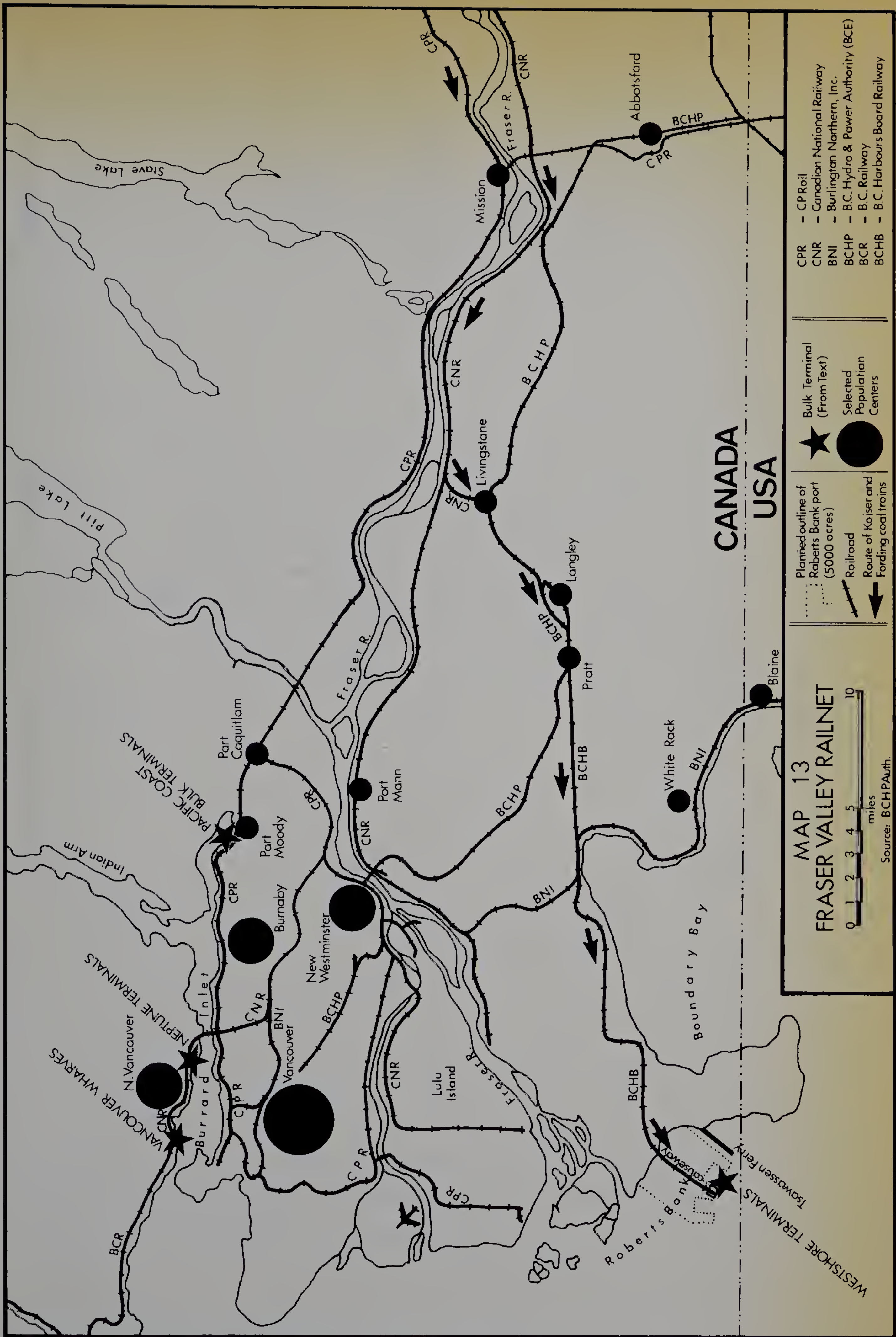
e. Remote from densely populated areas; minimization of occasional noise, air and water pollution.

f. Minimum disturbance to bird and fish life[25].

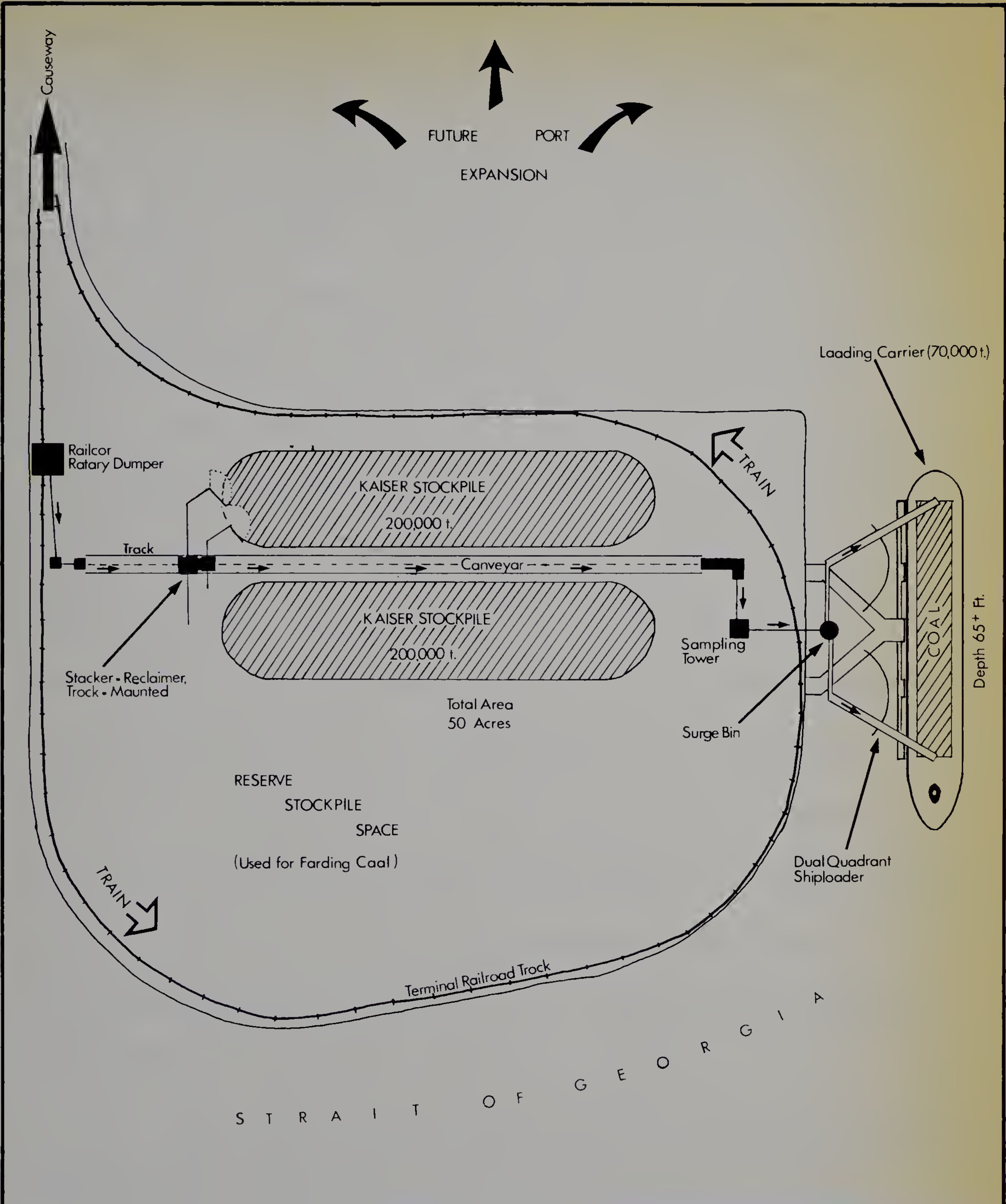
g. Relatively easy access for CP Rail, in particular from Mission City via an existing bridge across the Fraser River and via some trackage of CN, Great Northern and B.C. Hydro Railway[26] (Map 13).

A total area of 5000 acres was designated for harbor development and Kaiser Resources obtained permission to develop the first fifty acre site (Map 14), an island of fill linked to the coast by a three mile causeway. The design provided for a looped railroad (similar to the Sparwood loading track) with a ten degree curve, specified by CP Rail for unit train handling. The track loops around a central space which allows room for four rectangular stock piles of 200,000 tons each. Of these, two were to be used for the signed contracts, and two kept in reserve for future expansion.

The load-out equipment is a nice example of integrated handling of bulk materials. The top un-



MAP 13
FRASER VALLEY RAILNET
Source: BCHPAuth.
0 1 2 3 4 5 10
miles
Planned outline of Roberts Bank port (5000 acres)
Railroad
Route of Kaiser and Fording coal trains
Bulk Terminal (From Text)
Selected Population Centers
CPR - CP Rail
CNR - Canadian National Railway
BNI - Burlington Northern, Inc.
BCHP - B.C. Hydro & Power Authority (BCE)
BCR - B.C. Railway
BCHB - B.C. Harbours Board Railway
CANADA
USA
Abbotsford
Mission
Livingstone
Langley
Pratt
Blaine
White Rock
Port Mann
Port Caquitlam
Port Moody
PACIFIC COAST BULK TERMINALS
Burnaby
New Westminster
Vancouver
N. Vancouver
NEPTUNE TERMINALS
VANCOUVER WHARVES
Burrard Inlet
Indian Arm
Pitt Lake
Stave Lake
Fraser R.
Lulu Island
Boundary Bay
Roberts Bank
Causeway
Tsawassen Ferry
WESTSHORE TERMINALS
CPR
CNR
BNI
BCHP
BCHB
BCR



MAP 14 – PLAN OF ROBERTS BANK'S "Westshore Terminals" (Bulk Coal Port)

loading speed of 4500 tons per hour is a far cry from the previous maximum of 100 to 1200 tons per hour[27], although not as high as the rate used at Kaiser Steel's Fontana, California, works which reach 10,000 tons per hour, and is probably the fastest load-out system in existence. However, although the total unloading period for a train is expected to be less than three hours, an unloading time of four hours has been planned for. During this period the train enters the dumper facilities and the train crew hands over the locomotive control to the dumper operator before leaving. Another crew will take over at the end of the four hours. The cars and locomotives are piloted through the dumper by an operator who uses a trolley-type car positioner. Cars are not uncoupled and rotate through 155 degrees to dump their load in a hopper which feeds a high capacity conveyer belt leading to a stacker-reclaimer unit, originally crawler mounted. The positioning, dumping and moving of each car takes 100 seconds.

While the normal procedure is to feed the dumped coal to the bucket wheel and boom equipped stacker-reclaimer, a newly arrived train can have its load directly fed into a waiting freighter as well. Accuracy of positioning the car in the dumper is three inches. The

train is moved through the dumping procedure and is left to wait until the arrival of the new crew which takes it back to the Crows Nest area.

2-e Problems and Changes in the Total System

At the mining end of the system Kaiser Resources experienced a number of problems which produced slow-downs in the establishment of the system. Problems in mining methods due to unforeseen high stripping ratios, difficulties in the preparation plant due to design and a fire in the coal dryer in December 1971 were probably the most important stumbling blocks. Ash contents of the coal were nearer the twelve percent mark than the required 8.75 percent and briefly the future of the CrowsNest coal market as planned seemed somewhat in doubt. In agreement with the Japanese buyers, however, the ash limits were temporarily raised under the provision that they be lowered again as fast as possible. It seems at this time likely that Kaiser will not be able to reduce the percentage much below an average ten percent but that the Japanese industrial consumers will accept this figure because of the general scarcity of high grade metallurgical coal within their reach.

The original CP Rail plan foresaw eventually six unit trains operating between Sparwood and Roberts Bank

(see arrows on Map 12) as well as a start-up period during which only three trains would be in action. The six train system was based on two arrivals per day at dock-side but, with the 1972 entry of Fording Coal Ltd., which also began producing coal for Japan in the Crowsnest Area, the system now has three arrivals per day for a total of nine trains running. Continuous upgrading and maintenance of the tracks is mandatory for C.P. tracks as well as for the borrowed linkages near Roberts Bank, for the utilization of which CP Rail is charged on a user basis by CN and B.C. Hydro Railway.

Fording Coal's entry and usage of Roberts Bank necessitated the expansion of stock piling to include the two spare areas. The pile contents of 200,000 tons are limited by a number of factors, some of which also affected the choice of handling equipment. First of all, the height of the pile is limited under normal circumstances to ninety feet because of the possibilities of spontaneous combustion of the coal with greater internal weights. Larger stockpiles are only possible with special treatment of the material in terms of compacting, sizing and pile coverage as outlined by Berkowitz[28], as well as by Fryer and Szladow[29], at increased cost.

Secondly, in order to avoid too much coal remaining in "dead storage" in the large piles, due to probable settling of the fill base as well as for reasons of poor flow characteristics of coal, the piles were designed in such a way as to be operable with a stacker-reclaimer. This machine, in combination with the two shiploaders, can recover coal from storage at a peak rate of 6,720 tons per hour and was originally crawler mounted; shortly after start-up the machine was converted to the rail guided type for greater stability and more reliable coursing.

A problem hinted at earlier is that of air pollution with the loading, transporting, unloading and handling of many dry bulk materials. Coal as such is merely more noticeable because of its color. Just as countermeasures are required, either by law or for good public relations, at the site of stripmining after the area is mined out, the airborne particulate matter released during the various handling processes has to be counteracted. Loss of pieces of cargo was not much of a problem along the tracks because of the closed bottom design of the "bathtubs" or good standard gondolas; with hopper car operations losses occur frequently through incomplete closure of bottom doors, and with older gondolas

through the cracks in the construction caused by handling procedures through the years.

The dust losses or the loss of small chunks from the "bathtub" or other open top cars are generally considered to be low and estimated as around one percent and caused by wind action. Losses of this type during terminal handling are small as well, but information in this regard about Roberts Bank was not found. The common countering procedure at present appears to be the topping of the railcars with coarse coal during transit. Other possible methods are in the form of various sprays, applied as a seal coat[30], or the use of covers of steel, polyethylene or fiberglass[31]. Dust levels at coastal terminals are most frequently controlled by water sprays. Dust blowing off cars passing through areas of human settlement, however, still appears to be abundant according to some of the residents of those areas. According to newspaper reports such as those in the Vancouver Sun[32] citizens keep demanding action against both dust and noise which tend to make life unpleasant.

Other problems which should be mentioned at least briefly as having at times disrupted services and as being capable and likely to do so again are labor strikes

called by various unions, derailments of freight trains, and disruption of the tracks by weather conditions. Against blockages of the 692 mile route to the coast, however, CP Rail has provided a number of possible other routes by rail (Table VI) and a choice of two other port facilities in emergency situations; Port Moody (Pacific Coast Bulk Terminals) and Vancouver (Neptune Terminals). The operation is not considered likely to be disturbed to such an extent, however, since the 345 day operating schedule allows for a cushion of twenty days per year, while disturbances average only 3.9 days annually and the longest disruption, in 1963, totalled 10.8 days accummulatively[33].

3. The Economics

As was previously mentioned cost figures on construction and operation are, generally speaking, very jealously guarded. It is, however, possible to obtain some idea of the costs involved during the development of the CP Rail-Kaiser Resources system from published information. The figures are not complete, nor are they consistent, but it is believed that the figures are at least reasonable approximations for the various cost centers and investments mentioned.

Table VI
Alternative Routes from Sparwood to the Coast
(Source: CP Rail)

No:	Route Via:	Rail Trackage Involved	Approximate Mileage
1	Golden-Sicamous-Armstrong-Campbell Creek	CP Rail CN Rail	700
2	Golden-Basque-Langley	" " " "	712
3	Golden-Mission-Westminster Colebrook	" " " " & Burlington Northern	710
4	Cranbrook-Penticton-Spence's Bridge-Mission	" "	842
5	Fort McLeod-Calgary-Mission	" "	843
6	Fort McLeod-Calgary-Edmonton-Fort Langley	" " " "	1,170
7	Fort McLeod-Calgary-Edmonton-Kamloops Mission	" " " "	1,153
8	Fort McLeod-Calgary-Edmonton-Prince George-North Vancouver-Mission	" " " " & B.C. Rail	1,389
9	Eastport-Spokane-Auburn-Sumas-Mission	" " & Burlington Northern	756
10	Eastport-Bowners Ferry-Colebrook	" " " " & Burlington Northern	685
11	Nelson-Spokane-Colebrook	" " " " & Burlington Northern	832
12	Grand Forks-Colebrook	" " " " & Burlington Northern	Not known

In the Sparwood area and at Roberts Bank the bulk of the investments was provided by Kaiser Resources. At the mine site new mines, equipment, preparation and handling facilities and a new town had to be provided. Along the route to the coast CP Rail was required to build some new track, upgrade existing track and purchase motive and rolling stock as well as install centralized traffic control. At the coast Kaiser was provided by the National Harbours Board with the use of an island and a causeway, but had to construct a large bulk terminal. Both companies were forced to hire new personnel, although in CP Rail's case many of the new jobs went to people (already employed by the railroad) who only needed minimal instruction to enable them to operate the new trains.

The total investment in the Kaiser venture, excluding the CP Rail input was much higher than originally estimated by Crowsnest Industries ($60 million). By 1969 Urso gave an estimate on capital outlay for equipment and facilities, apparently for the entire project, of $100 million[34]. Rapidly escalating, the total cost was estimated at approximately $130 million during 1971[35], and at about $175 million in 1972[36]. Plagued by unusu-

ally many complications and problems Kaiser Resources came "on stream" originally with seemingly everything in its favor. However, as with many large projects, initial estimates are commonly optimistic. Gunn's early estimate to keep the cost of the Roberts Bank terminal below the $9 million[37] may have had to be adjusted as well since another source estimated the total cost to be about $12 million[38]; both figures would be in addition to the $3.8 million for developing the island and the causeway, paid for by the National Harbours Board. The Board is planning to expand the port by 1990 to approximately 5000 acres.

The agreement between Kaiser Resources and Mitsubishi of Japan, signed in 1968, provided for coal delivered on board the freighter (f.o.b. Roberts Bank) for $12.85 per long ton, starting 1970. This figure again, with the wisdom of hindsight, appears to have been somewhat optimistic, based on the calculated predictions as given in Table VII, without knowledge of the difficulties ahead. The Canadian producer was in direct competition with increasing production from Australian mines which had a distinct advantage in having rail distances of less than 200 miles to the coast. While ocean distance to Japan from the ports in both

countries is slightly over 4000 miles, the Canadian producers based an important part of their argument on the higher capacity of the Canadian railroads due to the fact that Australia's trains run on "narrow gauge" track (3 feet) while Canadian trackage, at least in the areas concerned, is "standard gauge" (4 feet 8.5 inches). In other respects, the two competing types of coal were of nearly the same quality and mining technology should be rated at approximately the same level.

Table VII
Cost Schedule per Ton of Coal Moved From Sparwood Via Roberts Bank to Japan
(Figures Rounded Off)
Source: CP Rail

	1965	1970 Forecast
F.o.b. mine price..................	9.00	9.00
Rail freight to west coast.........	5.50	3.50
Deepsea terminal (storage and handling).....................	1.00	.50
Ocean freight and demurrage........	4.00	3.00
Total........	19.50	16.00
Government subvention to producer..	2.50	0.00
Total........	17.00	16.00

Due to difficulties experienced by Kaiser Resources, coupled with rapidly increasing labor costs, the contract of 1968, quoting the price f.o.b. Roberts Bank as $12.85 per long ton, had to be renegotiated in 1970. The new agreement allowed Kaiser to ship

one half million tons less than scheduled during the 1971-1972 fiscal year, or longer if necessary to allow for readjustment of operations. At the same time the price f.o.b. Roberts Bank was raised from $12.85 to $18.65, or, in terms of short tons from $11.48 to $16.65 during 1971[39]. Shortly after the first contract for 3.36 million short tons per year, the coal producer had also in 1968, signed a second contract with the same Japanese consortium, which amounted to 2.24 million tons. Allowing for start up, the total amount of coal to be shipped amounted then to 5.60 million tons annually[40], reduced to close to five million tons for the interim adjustment period; the total term for both contracts remained fifteen years. In 1973 the total price f.o.b. Roberts Bank was raised to $17.73, to be increased by $0.50 in 1975, and to be reviewed in 1976 and 1980; included were, after the 1971 renegotiation, cost escalation allowances of up to $0.71 per short ton until 1975[41]. Total value estimates of the contract ranged from $650 million to over $1 billion over 15 years.

The influence of the fluctuation in production on the CP unit train system and therefore shipping of coal is not publicly known, and the financial implications are impossible to trace. At the beginning CP Rail

signed a service contract which began in effect in 1970 with the operation of three trains of the original design of eighty-eight cars. Train lengths were gradually increased (the longest test train was 160 cars), and by the beginning of 1971 there were on the route four trains of 104 cars plus one of fifty cars, taking slightly over three days for one return trip[42]. The original design called for six trains and no more than three days for a round trip. The sixth train was not added until later when extra trains were added for the Fording operation (Next Chapter).

CP Rail's contract provided for a basic charge of $3.50 per ton for the 692 mile, one way trip (Table VIII), for the first three million tons per year hauled from Sparwood to Roberts Bank, plus a cost escalation clause. For the next two million tons per year, during the same year, the base rate was set at $3.55 per ton plus cost excalation. (The higher rate for a larger shipment will be explained toward the end of this chapter). Both rates and cost escalations commenced in 1970 and would be reviewed after three years[43]. In other terms the first base rate amounted to $0.0051 or 5.1 mills per ton mile; the second base rate stood at 5.1 mills as well. By the middle of 1971, however, the $3.50 per

TABLE VIII
Rail Mileages
Sources: Railroads and General Literature

Canada

From:	To:	Miles:
Vancouver	Edmonton	764
Vancouver	Calgary	641
Vancouver	Ft. St. John	728
Edmonton	Calgary	194
Edmonton	Prince Rupert	959
Edmonton	Saskatoon	323
Calgary	Lethbridge	122
Calgary	Medicine Hat	176
Lethbridge	Medicine Hat	139
Medicine Hat	Regina	300
Regina	Saskatoon	162
Regina	Churchill	845
Regina	Winnipeg	357
Winnipeg	Saskatoon	472
Winnipeg	Thunder Bay	419
Winnipeg	Toronto	1,207
Port Moody	Coleman	704
Port Moody	Michel	682
Port Moody	Canmore	562
Trail (B.C.)	Coleman	292
Trail (B.C.)	Michel	270
Flin Flon (Man.)	Michel	939
Michel	Thunder Bay	1,300
Grande Cache (Alta.)	Vancouver	685
Luscar	Vancouver	690
Elkford (B.C.)	Roberts Bank	726
Sparwood	Roberts Bank	692
Ft. St. John	Ft. Nelson	250
Canada - U.S.		
Coleman	Fontana, (Calif.)	1,617
Michel	Fontana, (Calif.)	1,595
Canmore	San Francisco	1,535
Michel	San Francisco	1,200
Michel	Selby (Calif.)	1,450
Coleman	Provo (Utah)	930
Canmore	Pocatello (Idaho)	830
Canmore	Silver Bow (Mont.)	567
Canmore	E. Helena, (Mont.)	450
Michel	E. Helena, (Mont.)	404
Michel	Kellogg (Idaho)	280
Canmore	Butte (Mont.)	570

ton charge had escalated to \$3.67, which then became 5.3 mills per ton mile (unconfirmed in literature). Nevertheless, when the \$3.50 charge was instituted it was a reduction from the going rate of \$5.28 per ton from Michel to Port Moody (Table VIII) amounting to 33.7 percent. The \$5.28 per ton (7.7 mills per ton mile) was part of a ratio system which had remained remarkably stable since the late 1950's[44].

During 1970 CP Rail estimated unofficially that the following approximate new capital expenditures would be incurred, for each million short tons hauled by a unit train of ninety cars:

"Bathtub gondolas, 90 at \$19,000 each ..	\$1,700,000
Locomotives, 6(3000 hp each) at \$380,000 each	\$2,300,000
Parts and Miscellaneous	\$ 900,000
Total	\$4,900,000

In addition, operating expenditures for hauling one million short tons would amount approximately to:

Labor (approx. 128 jobs)...	\$1,370,000
Fuel & supplies	\$ 390,000
Material & supplies	\$ 680,000
Total ...	2,440,000

The estimate of operating costs does not include depreciation, cost of capital, and corporate income taxes. The jobs mentioned range from train crews to maintenance workers to office staff. Taxation revenues (Federal, Pro-

vincial and Municipal) flowing from the capital investment would approximate $1,370,000 according to CP., and those from the operating expenses $980,000. Not counted in, and indeterminable, are costs related to new trackage at both terminals, upgrading of trackage over unpublicized lengths, and many ancillary costs arising from overhead and other such sources.

Investment costs for the unit trains, as was said before, are justified only if they can be spread out over long term periods; ten to fifteen years is generally accepted as a reasonable length of time for a contract and in the case of the Kaiser Resources operation the term was set at fifteen years. As a rule the freight cars are given an economic life of twenty-five years, while the locomotives have to be written off within a period of twelve years. According to the private Travacon report[45] the annual depreciation on a $20,000 car amounts to $800, and on a $380,000 locomotive to $31,670. However, amortization costs would be annually $2,560 and $61,180 respectively, at twelve percent interest. The report states further that (presumably to a certain extent due to the railroad's accounting system) the capital borrowing cost for CP Rail amounts to twelve percent, versus seven percent for CN.

If the twelve percent rate is applied to the costs for the equipment, as stated above, the result is as follows:

90 cars (price, interest, depreciation over 25 years) cost per year...........	$217,600	
6 locomotives (price, interest, depreciation over 12 years) cost per year....	$364,167	
For a total cost of..	$581,767	annually
Parts and miscellaneous (assumed for 15 years at 12%) cost approximately........	$120,000	annually
Grand Total amounts to..........	$701,767	annually

The figure of $701,767 is part of the variable cost which must be compensated for according to the National Transportation Act, and it should be added to the operating costs of $2,440,000 for a grand total variable cost of about $3,141,767. Variable costs change in total with the output of the plant. The fixed costs are those which may vary on a unit basis with changes in production level but do not change in total[46]. The out-of-pocket costs in railroad economics would include the variable costs, but may also include certain portions of the fixed costs, such as depreciation, contrary to the view of standard economics.

Considering the rate set by CP Rail the company will receive $3,500,000 in revenue for the one million tons to be shipped in this example. The ninety car train can move, during the 345 day operating year and and with a three day operating cycle, 115 (days)

times 9000 tons (approximately) or 1,035,000 tons of coal if not seriously interrupted. At $3.50 per ton the rate amounts to 5.1 mills per ton mile. The variable costs add up to $3,141,767 or 4.5 mills per ton mile. As can be seen the difference amounts to 0.6 mills per ton mile; however this difference cannot be considered pure profit since a portion of the fixed costs, such as overhead, has to be recovered as well. The 0.6 mill figure is furthermore considered in the Travacon report as a reasonable approximation to account for slight discrepancies in railroad costing of unit trains due to "obscure cost elements" which are omitted in cost studies which are based on incomplete railroad information.

Incomplete as the above figures must be, they provide insight into the interdependence of low rates, high tonnages and long term contracts. It is considered here that the CP Rail rates for Crows Nest area coal are probably as low as they could reasonably be expected to go. The subsequent escalation of the initial basic rate of $3.50 per ton was to be expected in the light of inflationary pressures. The higher basic rate of $3.55 per ton for the second contract should also be considered a result of the necessary track improvements due to extra frequent, heavy loads.

Figures determined by Travacon, a private research organization, two years prior to the CP Rail estimates used above, indicate that CP operating costs of unit trains range from 3.1 to 3.8 (plus 0.6 for obscure costs) mills per ton mile. Taking into account the inflationary forces and the fact that the "Kaiser trains" represent the highest possible costs because of the terrain to be traversed, the figure of 3.8 mills is probably the most nearly correct one in the indicated range. Adding the 0.6 mills produces a figure of 4.4 mills per ton mile, or 0.7 mills below the real rate. However, at this point Travacon had not included any portion of the fixed cost recovery which would include the special tracks at both terminals and the mandatory upgrading of certain stretches of the existing lines, such as the long Windermere subdivision which was changed from 80 pounds to 100 pounds to 132 pounds. Although it is likely that some portions of these expenditures have been included in the transportation charge, the actual figure is not publicly known and the set rate may prove adjustable in terms of reduced recovery of fixed costs and profit in the face of serious competition.

The initial order for rolling stock and power units placed by CP Rail for the Crows Nest area-west

coast service covered sixteen diesels and 578 "bathtub" gondola cars at $380,000 and $18 to $19,000 each respectively in 1969. For the three trains originally planned a total requirement of thirty seven diesels was foreseen. The number of spare cars needed was calculated apparently at more than those required for a whole train and, considering that derailments have already cost CP considerable rolling stock, it does not seem to have been an excessive estimate. The exact number of diesels and cars ordered with the expansion of services is not clear and, as is shown above, the total costs could not be indicated by a railroad-outsider due to the methods of accounting used. In principle, the purchasing funds could be derived from any other operation of the company depending on the amount which can be incorporated with the fixed costs.

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CHAPTER VI

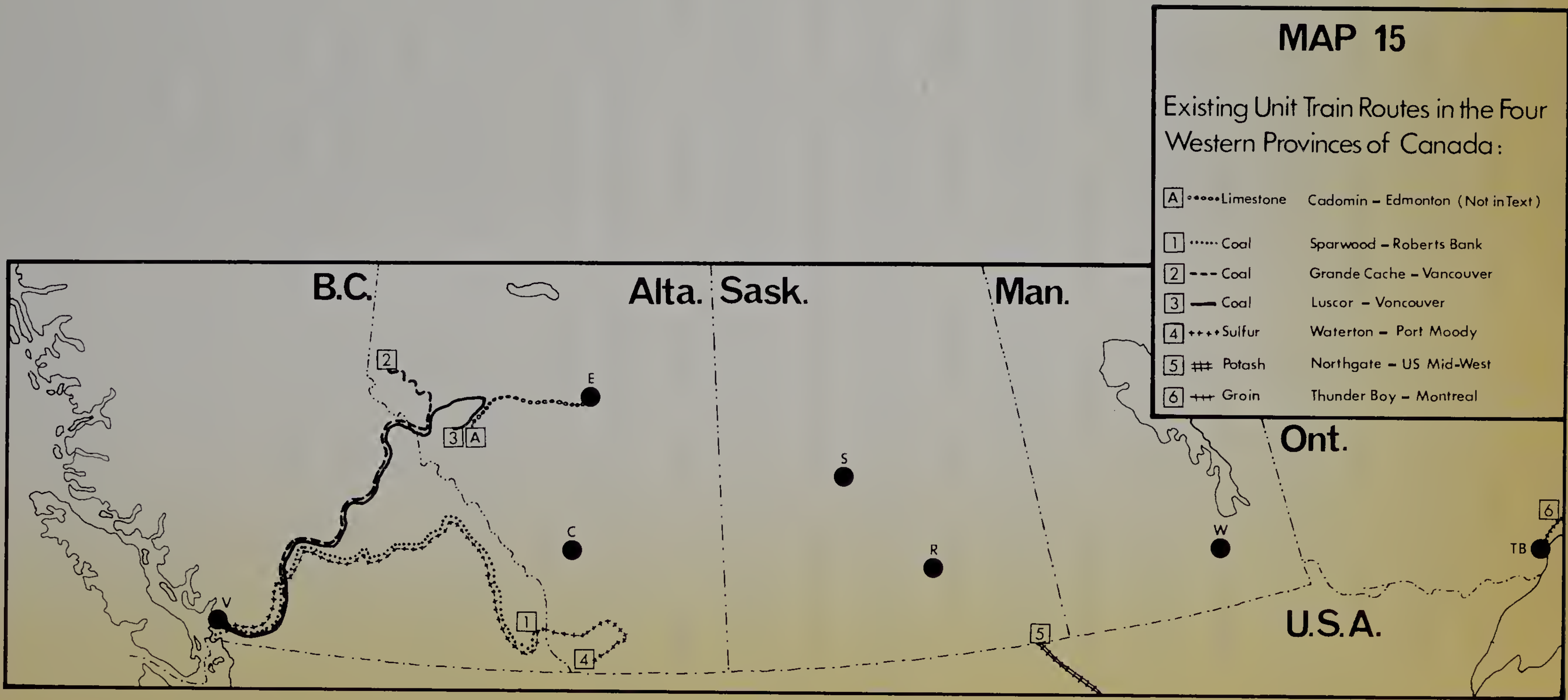
SURVEY OF WESTERN CANADIAN UNIT TRAIN OPERATIONS

After the passing of the 1967 National Transportation Act western Canada was not the first part of the country to get unit train service. While such operations in the United States date from the early 1960's, legislation in Canada did not allow a unit train system until 1967, when the sulfuric acid train from Copper Cliff to Sarnia was instituted by the Canadian National Railway and, officially slightly later, but apparently operating since 1954 as a regular bulk train, the iron ore pellet train from Temagami to Hamilton, which is run by the CN and the Ontario Northland Railway for Dofasco[1]. However, the CP Rail operation discussed in the previous chapter is something special indeed, due to the difficult mountainous terrain, the high tonnages shipped and the long train lengths. Some other unit train operations have started up since the CP Rail-Kaiser Resources venture "came on stream". In this chapter these operations are briefly discussed in re-

lationship to the commodities they carry or may carry, and the resource companies served (Map 15). Although the CP Rail-Kaiser agreement was dealt with before, it is summarized in this chapter for completeness of the survey.

1. COAL UNIT TRAINS[2]

Kaiser Resources Limited, seventy-five percent owned by the Kaiser Steel Corporation (American) and twenty-five percent by the public, owns outright Westshore Terminals Limited and has a fifteen year, 1970 - 1984 inclusive, contract with CP Rail to move annually 5.6 million tons of coal by unit train. The rail distance is 692 miles from the mine at Sparwood to the port of Roberts Bank (Table VIII). Trains are loaded at Sparwood while moving at a rate of 2500 tons per hour, and four hours are allowed for loading. The round trip to the coast, including four hours for loading and four hours for unloading, averages slightly over seventy-two hours (three days). Unloading occurs at a maximum rate of 4500 tons per hour, either directly into the ship or onto the two storage piles of 200,000 tons each. A total of thirty-seven diesels is required to haul the train, of an average length of 103 cars of 105 tons each, although the maximum at any one time is eleven motive units (Beavermouth-


MAP 15
Existing Unit Train Routes in the Four Western Provinces of Canada:
A Limestone Cadomin – Edmonton (Not in Text)
1 Coal Sparwood – Roberts Bank
2 Coal Grande Cache – Vancouver
3 Coal Luscar – Vancouver
4 Sulfur Waterton – Port Moody
5 Potash Northgate – US Mid-West
6 Grain Thunder Bay – Montreal
B.C.
Alta.
Sask.
Man.
Ont.
U.S.A.
E
C
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TB

Stony Creek). Freight rates were set in 1968 at a base of $3.50 per ton for the first three million tons subject to escalation each year. The next two million tons had a base rate of $3.55 per ton, again subject to escalation. All rates were to be reviewed after three years from the start of operation in 1970. Total contracted tonnage was not reached until 1973, due to problems at the mine site. Japanese importer is Mitsubishi, Price f.o.b. Roberts Bank in 1973 was $16.72 per ton.

Fording Coal Limited is located about thirty-five miles north of Sparwood and is owned sixty percent by Canadian Pacific Investments(Canadian) and forty percent by Cominco Limited (Canadian), in which CPI holds fifty-four percent. The mine is located near the town of Elkford, in the Elk River valley and has contracts with Mitsui and Marubeni of Japan for 3.36 million tons of coal annually for the period 1972 to 1986 inclusive. Overland transport is contracted to CP Rail which runs three unit trains for Fording along the same route as those for Kaiser. Originally it was expected that the Fording coal would be exported via the Port Moody bulk terminal owned by CP Rail, (dealt with in next section), but possible congestion, maximum freighter tonnage of 100,000 tons, and expected future contracts with new mining companies made

Fording choose to ship via Roberts Bank. After a total trip of 727 miles (Table VIII), the unit trains are unloaded via the same rotary dumpers as the Kaiser trains, also not uncoupled and the coal is stored in the spare stock-pile space at the terminal (two spare areas for stock-piles of 200,000 tons each). The extra time allowed for unloading permits the longer run Fording trains to fit within the total unit train schedule of nine trains, of which three arrive in the port each day. Price f.o.b. Roberts Bank in 1973 was $13.30 per ton.

Coleman Collieries Limited is eighty-two percent owned by Northern and Central Gas Corporation (Canadian) and owns and operates mines about twenty-three rail miles east of the Kaiser properties at Sparwood. Coleman has export contracts for the same type of low and medium volatile coal as the two previous companies but for smaller amounts. The deal with Marubeni and Tokyo Menka of Japan calls for 1.68 million tons annually, which is shipped via CP Rail to Port Moody where all handling is done by Pacific Coast Bulk Terminals Limited. The contract runs from 1967 to 1982 inclusive, and thusfar the total shipped per year has amounted to approximately 1.12 million tons. Blocks of gondola cars are dropped off by CP Rail and when loaded, picked up by the railway, in exchange for empty

cars, and shipped as part of other trains. This system could conceivably use a one unit train system but has not done so. Shipment is over 704 miles by means of block or modular trains; price f.o.b. Port Moody in 1973 was \$16.72 per ton. Transportation costs amount to approximately \$4.00 per ton in 1970.

The Canmore Mines Limited is owned by the Dillingham Corporation (American) and has a mine west of Calgary near the boundary of Banff National Park. The company produces low volatile coal and a semi-anthracite and has contracts for less than 0.2 million tons annually with Tokyo Menka in Japan. The term of the contract is from 1968 to 1977 inclusive and shipment is via block trains, similar to Coleman's system, to Port Moody via CP Rail. Unit train service would seem out of the question unless the company joined forces with Coleman. However the added cost of a originating terminal stockpile, shuttle rail-service and separation of the products makes it more advantageous to use the present system. Price f.o.b. Port Moody in 1973 was \$13.29 after a 562 mile trip, transportation amounted in 1971 to about \$4.60 per ton.

McIntyre Porcupine Mines Limited (Coal Division) is controlled by Superior Oil Company (American) and operates mines near Grande Cache, Alberta, along the Smoky River.

The company's contract with Mitsubishi, Marubeni, Sumitomo, Nissho-Iwai, and Kawatetsu of Japan calls for 2.24 million tons of coal per year over a perod from 1970 to 1984 inclusive. The transportation over land was contracted to Canadian National which would carry the coal over 685 miles to the Neptune Terminals Limited facilities in Vancouver's Burrard harbor. The terminal company belongs to Federal Grain Limited (Canadian) and the facilities are dealt with in the next section. The transportation system was combined with that of Cardinal River which is the next company to be discussed. The McIntyre Porcupine unit train service was contracted at a base rate of $3.13 per ton or 4.6 mills per ton mile. In addition CN would allow $0.56 per ton on shipments in cars furnished by the producer, bringing the charge down to $2.57 per ton or 3.8 mills per ton mile. The difference with CP Rail's 5.1 mills per ton mile is significant. Although CP Rail may allow a discount of up to $0.75 per ton on regular shipments in shipper provided cars, as compared to railroad owned cars, this option has never been mentioned for its unit trains. Reasons for the discrepancy cannot be explained in figures but some relevant factors can be easily found:

a. CP Rail had more new rail to build and more track to upgrade than CN.
b. CP Rail's interest on borrowed capital appears higher than CN's.

c. CP Rail's investment in rolling and motive stock is larger than CN's
d. CP Rail's route traverses a number of steep grades (2.2 percent, 1.6 percent) while CN remains below one percent.
e. CP Rail has to make a profit more urgently than the state owned CN.
f. Travacon's study indicated that CP Rail's cost ratios (dollars spent per item) are generally higher than CN's; for 1966 the results were as follows: (rounded off)

	CN		CP
Road maintenance per thousand gross ton miles	0.302	.....	0.254
Equipment maintenance per diesel mile	0.229	.....	0.241
Equipment maintenance per car mile....................	0.020	.....	0.213
Crew cost per train mile	1.545	.....	1.762
Fuel and supplies per diesel mile	0.305	.....	0.352

g. The approximately ninety-five mile line joining Grande Cache with CN's mainline near Hinton (at Entrance) was financed by the Province of Alberta, (Alberta Resources Railroad).

The cars for the McIntyre train were leased from Procor Limited (American) and the trains vary in length between eighty and one-hundred cars, with an average of eighty-five. The cars are loaded at a rate of 4000 tons per hour at the mine, twelve miles from Grande Cache, and unloaded at Neptune Terminals at a rate of one car per ninety seconds. Four hours is allowed for unloading. Total time for the return trip is scheduled at three days and transportation costs of $3.13 per ton are the lowest of any of the operating mines. Problems at the mine caused the company to cancel a tentative second contract with

the Japanese in 1973. Price of coal f.o.b. Vancouver was $16.72 in 1973.

Cardinal River Coals Limited, owned fifty percent by Luscar Limited (British) and fifty percent by Consolidation Coal Company (American), probably has had less technical problems than any of the companies mentioned thusfar. It has a contract for one million tons of coal annually with Mitsui and C.Itoh of Japan for the period from 1970 to 1984 inclusive and seems to have had no significant complications in its mining activities. Being, perhaps, barely suitable for a unit train service because of its low volume of production it has a system which is run by CN in combination with CN's McIntyre operation, the trains being unloaded at Neptune Terminals after a trip of 690 miles. A short railspur was built by CN onto the company's property but the grades on this short line are relatively steep. Facilities are such that the train has to be loaded in two uncoupled halves which cuts down efficiency. Due to the extra costs involved the tariff was set at a higher level than for McIntyre, that is at $3.55 per ton versus $3.13. It will be noticed that this CN charge is the same as the second base rate charged by CP Rail to Kaiser Resources. Terminal services can be considered equal to the McIntyre system and the price of

coal f.o.b. Vancouver in 1973 was $12.77 per ton.

2. TERMINAL FACILITIES AT THE WEST COAST

Although Westshore Terminals' facilities have been dealt with in the previous chapter the other coastal terminals have only been mentioned in passing. A few brief remarks about their operation are fitting at this point since their existence and efficiency is an important feature in the unit train economies, and one without which no such train services could be performed.

The Pacific Coast Bulk Terminals are a subsidiary of CP Rail located in Port Moody, at the end of Burrard inlet, and part of the Vancouver Harbor complex. This is the facility which J. C. Williams describes when pointing at the inefficiency of traditional railroading before the introduction of the unit train[3]. However, the situation has changed recently and major expansion has been completed to allow for modern methods and efficient handling. The old method was based on direct car-to-ship transfer and has been replaced by operations similar to those at Roberts Bank. The old method is still possible but, more commonly, the bulk cargo is put into storage on large stock piles. Trains arrive and leave within an eight hour period and the coal storage for Canmore and Coleman products amounts to 134,400 tons[4], while sulfur storage amounts to 78,400

tons and the potash stockpile can contain 89,600 tons. All storage is open except for the potash stockpile which is enclosed. Woodchips are handled in a separate area which can handle 10,000 ton barges. The other bulk facilities can supply ships of up to 65,000 tons, based on depth, and 89,600 tons based on berth size, which is still adequate for most shipments. Dual shiploaders can handle a total of 3000 tons of sulfur or potash per hour or 2000 tons of coal. Arriving trains are switched into the terminals' tracks and can go through one of several unloading facilities in the dumping complex, suitable but not used for unit train service, except for sulfur.

Of the several methods for unloading trains there is first of all the rotary dumper which can handle one car in ninety seconds, with the uncoupling, spotting and moving taking three to four seconds. On the average thirty cars are emptied per hour. Conveyor belts transport the unloaded materials in the stockpiles. Secondly, the hopper car unloader uses conventional methods and can unload one car in approximately five minutes if the material is free-flowing. Thirdly there is a boxcar unloader which tilts the car slightly sideways after which the Kar-Flo system is used to empty the car, that is the lining of the car is lifted in order to allow the material to flow

out. Reclamation is carried out by front-end loaders which can move 560 tons per hour maximum. Belt scales are used during loading and unloading. Dust is controlled by vents and wet scrubbers through which the fine particles are forced by air blasts.

The Neptune Terminals are a large seventy acre facility finished in the late 1960's at a cost of $15 million. It is located in the northern part of Vancouver Harbor and along CN tracks. It handles four major outgoing commodities (coal, sulfur, potash and grain) and one major import (phosphate rock) and is served by unit trains. Some other commodities handled are fertilizers, rock salt, and methanol, while ore concentrates are considered for the near future, making the terminal a true multiple commodity transhipment point. Information on exact storage capacity is not available for all commodities but the coal storage amounts to 500,000 tons in two piles[6]. Train unloading facilities are comparable with those of Pacific Bulk Coast Terminals as is the dust control system[7]. Maximum ship capacity for the terminal is 125,000 tons[8] and enlargement does not seem possible due to harbor conditions. Ships can be loaded via one of two 4000 tons per hour ship loaders either from storage or directly from the train. A stacker-reclaimer, similar to the one at Roberts Bank, can

handle 4500 tons per hour both ways.

Vancouver Wharves Limited, owned by British Columbia Wharves Limited (Canadian)[9], is one of the longest established terminals, located at the northside near the entrance of the harbor. It is served by the British Columbia Railway and the Canadian National. It handles more commodities than the previously discussed facilities, and serves as a container terminal as well. Although it has facilities capable of handling unit trains, such services have not been added[10]. Handling capabilities are similar to those at Neptune.

3. SULFUR TRANSPORT

To date only one sulfur unit train system has appeared on the scene in western Canada. In 1970 Shell Canada's Waterton Gas Processing plant, located in southwestern Alberta, began shipping its sulfur via CP Rail unit train to the Port Moody terminal[11]. The operation calls for three sixty-five car train sets with each train moving 5,500 tons of sulfur. A total of 205 hopper cars was permanently assigned to the service, including ten spares. Shell is hereby making use of new tariffs which were announced in 1968, replacing the previous flat freight rate for prairie sulfur of $9.00 per ton. The charges were set at the following levels: ten car lots at $8.10, twenty

to forty-nine car lots at $7.85, and fifty or more car lots at $7.50 per ton[12]. In addition CP Rail would charge $8.00 per day per car demurrage for any car held at the port terminal for longer than twenty-four hours before unloading, excluding Sundays and holidays, in comparison to the existing ten free days and a rental of $5.00 per day per car.

The sulfur market, being as "soft" as ever, has never included long term, large contracts but was supplied generally by small freighters. Consequently, storage at the port was extremely important in order to be ready for any sales which might come about. With handling costs at the terminal of $3.00 per ton the cut in transportation rates could give Canadian sulfur a much needed boost on over supplied world markets; as the figures in Table IX show prices of sulfur at the plant have been fluctuating wildly.

While the freight rates on sulfur had been lowered in 1968 it was two years before the first producer in fact began to use them on an organized large scale, due, perhaps to lack of coordination among the companies. Plans for the Shell Waterton-Vancouver unit train service were finalized during 1969 and included shipment of a total annual minimum tonnage of 500,000 tons of sulfur. The route was planned

TABLE IX
Sulfur Values f.o.b. Plant in Alberta
(Source: Alberta ERCB)

Note: Earlier values not available

Year	Dollars Per Short Ton Yearly Average
1956	19.16
1957	22.68
1958	19.96
1959	19.47
1960	15.64
1961	18.09
1962	13.23
1963	10.36
1964	9.88
1965	12.39
1966	19.25
1967	27.17
1968	30.84
1969	20.49
1970	7.97
1971	6.45

to be the same as CP Rails other unit trains planned at that time, that is, through the Crowsnest Pass and the Rogers Pass ("Beaver Hill"), with six locomotives pushing the train up the 2.2 percent grade, three at head-end and three ahead of the last twenty cars[13]. Apparently it was then also decided to add a North-Vancouver terminal, Vancouver Wharves Ltd., for which CP Rail has to utilize CN track.

As part of a program of modernization CP Rail built new yards at Calgary, considered to be the most computerized and automated facilities of this sort in Canada, able to handle 3000 cars daily by 1971. The terminal is comparable to the Penn Central Perlman Yards, referred to in Chapter II, in the design of which CP Rail apparently co-operated with that company. These new Calgary yards play an important part in another sulfur transport contract Canadian Pacific signed in 1970. Together with CN the company agreed on a rationalization program for the movement of sulfur with Trimac Limited, a company which acts as transport coordinator and shipper for some two dozen sulfur producers.

Many sulfur producers are simply too small to sustain an efficient transportation system on their own. Their marketing and sales were carried out on an individual basis,

and, due to the involuntary nature of the production, some sales were considered better than none at all, that is small profits or none at all were better than leaving the sulfur piling up at the plant. With the reliability and the spot character of the sales much of the product was sold below potential price. The gas plant operators rate as sulfur producers in output on the basis of amounts of gas produced and gas qualities of one to eighty-seven percent hydrogen sulfide[15]. These companies decided to go along with the following proposal of Trimac: To form a "banking" system according to which each producer has an interest, based on his production, in the production of all participants as well as in the dock-side stockpiles, while the product will only be shipped from a few large plants. In fact it is a pooling of both product and transportation thereby achieving a remarkable degree of efficiency[16].

It should be noted at this point that the Trimac system is essentially different from the plan which the Alberta government proposed in 1970 and which would have given the government complete control over the inventory of sulfur. The idea was to remove from the market a significant portion of product which was in excess of current market demand with the object of stabilizing the world market, parallel to the Saskatchewan pro-rationing policy for po-

tash which controls production. The Federal government was quite concerned about the Alberta move and the province did not press ahead with it.

According to the Trimac plan, in which this company acts as a shipper, CN runs one ninety car train with a capacity of 8,500 tons, once per week, from the Texas Gulf Sulphur Company plant at Windfall and the Kaybob South plant of Hudson's Bay Oil and Gas Company Limited. CP Rail runs two sixty-five car trains with a capacity of 5,500 tons, loading sulfur two times per week each (in principle) from the Petrogas Processing Limited plant east of Calgary and the East Crossfield plant of Amoco Canada Petroleum Company Limited. The CP sulfur trains run between the prairies and Port Moody while delivering, at times, in North Vancouver as well. The trains operated by CN run to North Vancouver, supplying both large terminals there.

When these Trimac proposed trains began operation they were based on a split-up of the trains in the area of origin, with a recoupling after loading. Such solid trains were expected to develop into unit trains within a short period. However, no information was obtained that this change indeed took place. As such the Shell-CP trains appear to be still the only unit trains for sulfur, which make two-times-per-week round-trips in principle, but may

vary their frequency depending on the whims of the sulfur market.

4. POTASH TRANSPORT

The situation of the potash producers has been dealt with earlier and, under present conditions, it does not appear due for much change. No company is able to produce presently enough to support a unit train system. Multiple car shipments and solid trains are common but the only unit train connected with the industry is the International Minerals and Chemicals (Canada) Limited train. As was pointed out, this company ships much of its product by truck to Northgate, North Dakota, where it is loaded into a 15,000 ton unit train and is shipped into the American mid-west via the Great Northern and Burlington Railroads[17]. It is interesting to note that Sherrit Gordon Mines Limited uses for its phosphate rock movement from Vancouver to Fort Saskatchewan an empty CN potash train. This train is on back-haul to Saskatoon to pick up a new load of potash and by using the cars on the return trip the load factor of that train is increased from 50 percent upwards to about 85 percent. Contamination of the phosphate is a problem at times since potash is not compatible with phosphoric acid production and some potash tends to remain in the hoppers[18].

The potash producers have devised a common marketing organization, Canpotex Limited, which has been distributing and selling the product since 1970, when the Saskatchewan government introduced its minimum price for potash at the mine. The price of $62.78 per ton of KCl in 1965 had dropped to $33.18 in 1969, while the provincial government set price was determined at $56.36 per ton of standard grade KCl by 1970. The move was intended to help stabalize world prices. Transportation costs to Vancouver in the early 1960's set by the railroads at $9.00 per ton of product for the approximately 1100 miles distance. Rates to key points in the U.S. at that time were as follows: $12.62 to Minneapolis, $12.98 to Sioux City, $13.50 to Chicago and St.Louis, $16.49 to Cincinnati. By 1968 the rates to the U.S. were boosted by about 15 percent, with the Canadian rate to the west coast reaching $9.54 by 1970, with a possible drop to $8.48 in return for greater efficiency in scheduling rail-movements. Another increase of six percent on the shipments to Vancouver took place at the end of 1970, while movement to Ontario was at that time $21.78 per ton.

Potash has, to a larger extent than sulfur, a market which fluctuates with the seasons. Most ocean shipping for both products is in ships of less than 20,000 tons, although ships of about 40,000 tons or slightly larger have

been used for cargo destined for ports with adequate berthing. Ships are generally loaded from stockpiles along dockside, but unitization has run into problems at the producers end due to a scattering of pick-up points. The governmental action was designed to protect producers against strong price declines by limiting production to 40 percent of capacity plus an allowance for past sales performance (averaging in total 45 percent of production). It has succeeded to a certain extent, but had the unfortunate side-effect of virtually eliminating the possibilities of pooling inventories and transportation as is done by Alberta sulfur producers.

5. TRANSPORT OF OTHER COMMODITIES

Two major commodities in the west remain to be mentioned in the context of unit trains. Forest products such as lumber and woodchips have not yet experienced unit train service. One possible reason for the lag in this field is the seasonal fluctuation in production coupled to fluctuation in amounts from particular areas. Companies tend to prefer traditional river-driving or truck transport because of either their investment in a fleet of trucks or proximity of suitable rivers. As W. G. Paterson[19] states: "Radically new methods of overland transportation normally go through a gestation period of four to seven years, followed by

prototype modification and then gradual widespread adoption". He estimates that the industry would be using a new method by 1980 only if it were already in evidence in 1970.

Even though the proportion of pulpwood transported by rail has been declining steadily, J. D. Masson claimed that a number of factors could improve the situation for the railroads by making them an attractive choice for the forest industry[20]:

1. In 1971 pulpwood and woodchip truck transport, involving hauls of 100 to 300 miles, was too expensive at $5.00 to $8.00 per ton, or five cents per ton mile and up. Railroads could reduce that price by $2.00 to $3.00 per ton.
2. Existing truck fleets could be used to complement rail lines which have a much higher capacity.
3. Railways can operate in all weather and altitudes, limiting inventory needs and producing cost savings of $1.00 per ton of production.
4. Optimum costs are developed through shipper ownership of rail equipment by multiple firm participation, preventing extended stalling periods for cars in the producers' yards.
5. Rail systems are pollution free.

Of course, Masson as an employee of CP Rail is keen on pointing out rail-over-truck advantages, but already in 1968 the pressure for guaranteed minimum tonnages was being felt by the forest industry itself. This parallels railroads' requirements, and the forest industry is attempting consequently to shift to an all-weather multi-shift system of harvesting[21]. In the Southern United States

there are many hauls of 150 miles or less which have been serviced by the railroads for years, trains moving directly from a concentration yard with stockpile to the mills without yarding or switching. However, up to the present the forest industry has not been able to guarantee a certain basic specified utilization of rail equipment which would allow the railways to recover its investment over a reasonable period[22].

For comparison with the previously mentioned charges for trucking and the 0.7 cents per ton mile for river driving (eastern Canada) a number of charges agreed to by the railroads for pulpwood are quoted below from Martin[23], (Table X). Comparing possible eastern Canadian solid or unit train costs with those existing in the southern U.S. he comes to the conclusion that not only the forest industry but also the railroads ought to think in more competitive terms since the rates appear quite out of line. U.S. mileages in Table X are put next to a comparable Canadian distance.

The second product remaining to be discussed is western grain, again a commodity which is entirely seasonal in production. However, although long term contracts are not common in the grain trade, shipments are usually large and require a large stockpile at dockside as well

Table X
Agreed Charges for Rail Transport (1971)

CANADA Distance in Miles	CANADA Cost per Ton Mile (Mills)	U.S.A. Distance in Miles	U.S.A. Cost per Ton Mile (Mills)
58	26	50	22
121	26		
171	18	150	11
204	20		
247	11	250	9
358	13		
419	16(+ $5.00/car user charge)	400	8

as reliable and efficient transportation from inland storage to replenish the coastal silos. Unfortunately the pricing of the transportation has been low. Grain producers are widely scattered and individual volumes of produce are small. The problem is similar to that of sulfur producers just discussed, but it is much more difficult.

There are nearly 5000 elevators in 1900 locations across the grain growing areas of western Canada, from Winnipeg to Dawson Creek, some standing alone, others standing in small clusters. An example of the elevator pattern is the system of United Grain Growers Limited which, in 1971, had 813 country elevators located in 534 places according to the company's 65th Annual Report[24]. In addition to these "gathering places" the company owns a terminal elevator in Vancouver as well as three terminals at Thunder Bay. Through

these four terminals flows most of the grain from United's country elevators on the way to foreign and domestic markets, although some grain is shipped through Churchill and Prince Rupert. Other companies have a similar organizational pattern, making use of terminal facilities at Thunder Bay, Vancouver, Churchill, Montreal and other places.

It was mentioned in the beginning that the prairie network of railroads grew with the regional economy and, accordingly, many branch lines were built to service country elevator locations and the small settlements which tended to establish themselves around the elevators. According to Purdy the prairie system was built without even an overall plan[25]. Up to the Second World War there was general agreement that the elevator and and rail system were equal or superior to any other in the world, but later on, and especially during the 1960's complaints were more common than praise. In 1970 Heffelfinger stated what had become a rather common view: "Today most of the elevators are anywhere from twenty to fifty years old and are in deteriorating state of repair. In terms of the technology which is now available, our elevator and transportation system is inefficient and obsolete."

Grain transportation was in a situation comparable to the cited example of coal movements at the coast during

the 1960's and improvements appeared just as unlikely; even more so because of the fact that the 1967 National Transportation Act recognized the statutory nature of the famous low rates based on the Crowsnest Agreement of 1896. Furthermore, uneconomic rail branch lines could not be abandoned due to an Order-In-Council of 1967 prohibiting such action until at least January first, 1975. Each recent Canada Yearbook presents statistics on the amounts of grain produced and passing through the terminals. Every year these statistics show large amounts of grain left in storage at the terminals as well as inland, produce which could not be sold in part because of unavailability of rolling stock in the right places. For this reason the Federal Government is presently attempting to add over 4000 cars to the existing fleet of approximately 22,000 cars used for grain.

Shortly after the passing of the Transportation Act the Wheat Board established a study group, called the Grains Group, to study the grain trade situation. The group's task was to study the problems inherent in the existing conditions and to determine a number of situations (pure models) which would be more suitable in the Canadian context. It was not the intention to have the group define an ultimate or optimum system, nor was the group

expected to present conclusions to that extent[26]. Covering the subject in thirteen separate studies the group subsequently dealt with all probable modes of grain transport as well has handling system configurations and the results of certain changes in various aspects.

As Shepp stated already in 1970 there were a number of aspects to the existing methodology which caused the recurring stagnation, all based on institutional factors[27]:

1. The grain producing community had regulated and statutory rates and saw no advantage in system changes. Consolidation seemed to mean longer hauls and more producers bidding for less space, causing increased costs.
2. Free market forces were muzzled by regulation which kept revenues down below free market income and investment capital was not generated.
3. Separate charges for storage and handling were levied, with storage being the more profitable of the two. It was to the advantage of the companies to maximize storage. With the subsequent less available storage the producers supported construction of additional storage, thereby counteracting any consolidation. It led to larger, but no less numerous elevators.

Shepp indicated, in addition to the above, that changes were inevitable because of the pressures exerted on the existing system, pressures which would even grow larger with gradually increasing production.

The results of the study by the Grains Group are apparently still considered "classified" as a result of the relatively detailed costing information obtained. However, an adequate reflection of the studies can be found in the

cited summary and is interpreted as outlined below.

At first, the study seemed to be following, in principle, an inland terminal system of twenty-two terminals combined with unit train movement. It was realized, however, that trucking costs would affect individual producers quite unevenly and that congestion might be a real problem at these terminals. As a result of subsequent changes the most economic choice appears to be an inland terminal system of 80 to 100 terminals with cleaning facilities, while the unit train would be similarly used. Total storage capacity, at 2.5 million bushels each, would be 200 to 250 million bushels as compared to the present 400 million bushels for a total producing area of 190,000 square miles, and unit train service would be retained. Although the study is to be considered approximate only, the figures in Table XI appear encouraging. The system would lower costs considerably below present regulated rates and allow the railroads to abandon about 5,500 miles of uneconomic track out of the 19,300 mile involved network. The advantage of the new method amounts to a decrease in transportation and handling of 10.5 cents per bushel.

With the continued increases in size of freighters the new system may become mandatory in a couple of decades, as are the highthrough-put facilities at dock-side.

Table XI
Cost Comparison of Present System and Small Inland Terminal System for Grain

Average cost per bushel in cents, based on annual volume of 675 million bushels

Source: Grains Group

	Present Elevator	Small Inland Terminal
Prairie storage and handling	12.4	-
Prairie storage, handling and cleaning	-	11.5
Transportation	29.9	17.7
Port terminal handling storage and cleaning	6.9	-
Port terminal handling and storage	-	5.7
Farm trucking increase due to greater distance	-	3.8
Total	49.2	38.7

The port terminals have, during recent years begun to upgrade their service facilities and their handling facilities have become very much like the bulk facilities described previously. Shiploading has also become more advanced with systems capable of handling 59,000 bushels per hour[28]. At an average of 55 pounds per bushel this figure would amount to approximately 1,600 short tons.

In studying the practical aspects of transportation the Grains Group enlisted the cooperation of the CN, Federal Grain Limited and its subsidiary Neptune Terminals Limited. A successful experiment was conducted in December of 1970, with the shipping of 279,000 bushels of wheat aboard a 90 car unit train of potash tank cars from Saskatoon to Vancouver, a distance of 1087 miles covered in three days. Loading took five hours and unloading, at twelve cars per hour nearly the same time. Presumably based in part on this experience, CN is operating a grain unit train from Thunder Bay to Montreal for the Wheat Board. The train is composed of sixty-five cars and the service was established in January of 1972.

Encouragement for the implementation of the ideas of the Grains Group would depend, according to its report, on the following points:

1. If the amounts of grain shipped eastwards do not increase a switch from water to rail would not be economical since it would render the Canadian lake fleet almost obsolete.
2. Unit trains can be used for shipping from the prairies to St. Lawrence ports during the winter.
3. Unit trains could ship additional amounts which would require further ship capacity.
4. Unit trains could be applied, if point 1 is considered, to ship from the prairies to the Eastern Canadian feed mills.

It can be termed unfortunate that companies like United Grain Growers, as is mentioned in their cited 65th

Annual Report, consider the Grain's Group's study "nothing but an academic exercise". However, they do appear to have a valid point of contention when they emphasize that the Group does not state clearly any suggestions for financing the necessary new capital investments.

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CHAPTER VII

CONCLUSIONS AND PROSPECTS

The unit train systems and their closely related variants have been developed only during the last one-and- a half decades, but clearly their impact on the ability of railroads to handle bulk movements has been significant. Already in the 1950's the railways were worried by the gradual decline in the railroads' share of the bulk freight market, and even in some cases by a decline in absolute terms. With the sudden appearance of solids pipelines many thought that the railways had entered the last stages of a losing battle, especially in the competition for new, large coal contracts with thermal power stations, such as those signed between companies in the eastern U.S. The railroads had not been very dynamic in their marketing techniques and in 1957 two solids (slurry) pipelines began commercial operation.

The first of these slurry pipelines was a seventy-two mile project to transport gilsonite, a solid hydrocarbon, in Utah via a six inch line. Annual volume was

only 0.38 million tons per year but the start-up was a significant fact[1]. In the same year, 1957, Consolidation Coal Company began operating a 108 mile ten inch slurry pipeline for coal between Cadiz, Ohio, and a power station in Cleveland. In the latter case the business was taken away from a railroad (B. & O.) because of the lower pipeline rates. The pipeline lasted until 1963 before the railroad could recapture this particular service by introducing rates below those of the pipeline. However, by that time the pipe had already handled a total of 6.5 million tons of coal[2]. The fact that the railroad could regain the business in Ohio, and have the pipeline "mothballed", as well as increase its services in the area was due to low rate unit trains.

This brief episode was enough to convince the railroads of the serious nature of the forthcoming competition and unitized railroading was siezed upon as the only way not only to stay in business, but also to expand existing haulage, to regain lost traffic, and to create shipper demand and, as such, new business[3]. It would appear that the railroads have indeed chosen the right path for their improvements since the new system of unit trains consists essentially of eliminating inefficiency, replacing it with positive action, and thereby reducing unit freight costs.

In a system utilizing unit trains many impediments to smooth operation are removed and as such there is no yarding, unneccessary switching and humping of trains, with frequent "loss" of cars, unbelievably long waiting periods for rolling stock, mixing of cars with different loads and destinations, and interference of trains standing on the track with the handling of later arrivals. In unit train systems the rolling stock is, by contract, assigned to a specific service, which, in order to make it economically feasible, has to involve large tonnages, long term shipments and regular supply and demand. In the ideal case, the integral train, the smooth management is augmented with specific, sophisticated technological features, but unit trains have frequently had such new technology incorporated in their system as well, be it to a lesser extent. Constant motion is a requirement for the trains and the least amount of unnecessary yarding and handling compromises the service, reducing it to the more traditional form of bulk solid trains. On the lines unit trains are commonly given the right-of-way at the expense of other traffic on single or up-hill track. Another feature introduced with unitized railroading is the greater than usual cooperation between railroads with respect to the use of each other's tracks. Such service is generally paid

for on a user's basis or by exchange of track use.

As in the United States, legislation had to be relaxed in order to allow unit trains to be run in Canada. This was accomplished by the National Transportation Act of 1967, which allowed the railroads to lower rates for shipments of large blocks of cars or train load lots of commodities. Where previously the car-load had been the basis for rate setting, the railways are now able to use normal economic principles of reducing charges in return for assurances of large volumes over minimum periods, that is using economies of scale provided the cost of service is recovered via the rates charged. Limitations on unit train service, at present, seem to be more in the nature of practical and technical possibilities than of political and legislative restraints

Practical tonnage levels have been established (Table IV) as well as minimum contract periods for transport of at least five years. The tonnage level limitations depend on many aspects of which the following are significant: number of tracks and sidings; lengths and sizes of grades; type of track and roadbed; size of curves along the route; amount of other traffic using the same route; terminal capabilities at both ends of the route, as well as the size and expansion possibilities of the consumer;

weather conditions; labor climate; availability and nature of competition; presence of railway track.

In western Canada unit trains were first tested by CP Rail when it became clear that a possible market for this service could be realized in the near future. The first commerical operation was also by this company for Kaiser Resources, as described in Chapter V, followed by other coal trains and sulfur trains. The unit train service in each of these situations is considered essential for the competitive marketing of the commodities hauled, whether it is for continental or off-shore sales. Smaller producers not capable of engaging a unit train by themselves, can make use of this innovation by providing centralized train loading facilities or by means of a pooling system similar to that used by sulfur producers in Alberta (Chapter VI). Existing services such as the one used for Dofasco in Ontario (Chapter VI) have successfully been upgraded by the companies involved from a traditional bulk movement to a full fledged unit train system.

The success of the new railroading methods can be emphasized by another American example. In 1970 the 18 inch, 273 mile coal slurry Black Mesa (Arizona) pipeline began operating between a Peabody Coal Company mine and a power station on the Colorado River. The pipeline was

chosen over unit train service as being lower in cost due to the fact that too much additional track would have to be laid. The total volume of coal is close to five million tons per year[4]. However, expansion of the mine's production is based on a new 80 mile track, which will be used by 1974 for unit trains providing coal to another power station expected to consume 7.8 million tons per year by 1976[5].

An example in western Canada is the case of the Cascade Pipeline Limited, a subsidiary of Canadian Pacific. A slurry pipeline was planned to follow a rather direct route from the Crows Nest area to Roberts Bank, shortening the rail distance of 692 miles to 490 miles, and costing $200 million. Officially, the purpose of the pipeline was to augment unit train capacity by up to fifteen million tons annually, almost doubling the railroad's estimated capacity. Unofficially it may also have been an attempt to forestall any attempt by another company to install a competing system. However, the pipeline has not been built to-date because of suspected detrimental effects of pipelining on metallurgical coke qualities and because of problems with wastewater at Roberts Bank. In all previous slurries the coal was to be utilized for thermal purposes only. The train system has no effect on those qualities

and as such suffers little if any threat of competition in this area as yet.

In general one can say that, although there exist cases where the railroad would lose in competition with a solids pipeline, the railroad can usually put up a stiff battle and come out victoriously in many cases. Whenever there is a railroad in the vicinity there appears to be little tendency to even consider a pipeline, but if more than forty to fifty miles of new track has to be laid the alternative is investigated. At that level, other factors tend to reduce the emphasis on construction costs, such as total tonnages expected for the link, duration of transport contracts, potential varieties of shipments in the area, environmental aspects, and preparation, recovery and intermediate systems. For a railroad one can say that a good branchline can still be constructed for \$100,000 to \$250,000 per mile, while an eighteen inch pipeline would require approximately \$60,000 per mile, with capacities of ten to twenty million tons annually and about ten million tons per year respectively[7]. By comparison, the construction cost of roads would be in the range of an eighteen inch pipeline. Although both the pipeline and the railway would be dependent on longrange transport contracts, the railroad obviously has a higher flexibility in adjusting

to instability of markets and sources, and in expanding capacity. Furthermore, the railway is not usually dependent over most of its length on one particular product, and it is potentially a two-way system unlike the pipeline.

Competitive transportation rates for different modes were determined on the basis of theoretical and practical data in the late 1960's and the data are still relatively valid for the early 1970's[8]. For the movement of one ton over a distance of 100 miles costs were as follows[8]:

Truck:	\$5.00 to \$8.00
Standard bulk train:...............	\$0.90 to \$1.40
Unit train:	\$0.50 to \$0.90
Ship:	\$0.20 to \$0.50
Pipeline (including preparation and recovery of commodity).........	\$0.70 to \$1.10

The overlap between the rates for unit trains and pipelines is obvious and indicates the role of many factors other than actual construction costs. The rates as quoted are only general approximations and may vary widely depending on engineering, economic and environmental considerations. Costs, for example, have a tendency to escalate rapidly when terrain conditions create difficulties from the engineering point of view; a case in point could be the construction cost for the Cascade pipeline, estimated at

about \$410,000 per mile, and the cost of constructing the Crest (Yukon) to Skagway (Alaska) railroad which amounted to \$460,000 per mile of standard gauge track[9].

A disadvantage to the railroad in some cases is the traditionally circuitous route followed by the rail-lines because of difficult terrain. As the Cascade pipeline shows, a pipeline route is considerably less affected by such obstacles and can shorten the distance as compared with the railway route. However, the longer route may prove to be more economical where the rail network is in proximity to the bulk producing area, which would be the case in many parts of the continent.

Another aspect of pipelining which may also affect the rail system is the system of capsule pipelining which is being developed primarily by the Research Council of Alberta[10]. In this mode slugs of material or an encapsulated commodity may be transported in a liquid medium without any contamination of either commodity or carrier liquid. The system is in an advanced state of experimentation and may appear commercially in the not too distant future.

The railroad, however, may also prove a formidable competitor in the traditional realm of the pipeline as is exemplified by a CN Oil unit train in Ontario,

operating since 1971[11], and the report on the artic railway for oil[12], as well as the oil train proposals of the British Columbia Government[13]. These examples show that, under certain conditions, the railways can be preferable in technical, environmental and economic respects to pipelines in the transportation of oil.

A notable competitor already, pipelines may be even more competitive for coal transportation than they are to-date. Technological progress in connection with the gasification of coal has been significant. While in the United States a number of pilot projects are operating surface plants for this purpose, the Research Council of Alberta is actively involved in the development of an underground process which would eliminate the need for elaborate surface plants[14]. With such a system, distribution costs would very likely be kept at a level with which the railroad could not compete. However, a date for completion of this project cannot be fixed as yet, since certain problems relating to heat content losses, as compared to coal, have not been solved yet.

It would appear at this time that the unit train can benefit and develop from the following existing conditions:

1. A widely spread network of branch lines and spurs,

which can be relatively easily upgraded if necessary
2. An efficient, low cost transportation system which can serve as a one-or two-way, triangular or radial system, flexible enough to cope with possible, although undesirable fluctuations in traffic.
3. Intermodal transportation possibilities, such as truck-rail service.
4. Known and reliable technology.
5. An infinitely wide variety of commodities can be shipped.

Frequently the areas to be served have already a certain amount of track available, but, if this were not the case, the railroad could continue with its traditional role in assisting with the opening-up of frontier areas, as is done by the British Columbia Railway in the North[15].

Although, the future cannot be predicted with great accuracy because of the rapid developments in the field of transportation and it appears a reasonable assumption that unit train railroading in western Canada will expand considerably with the movement of greater tonnages of coal. Canadian mines are expected to step up production, not only for the purposes of export, but also for national uses. In 1971 Stelco purchased nearly 200,000 tons of metallurgical coal from Kaiser Resources for its Hamilton steel plants while Ontario Hydro purchased a slightly smaller amount from Saskatchewan mines in 1970. Unit trains were experimented with in both cases to the satisfaction of all parties concerned. With increased fuel shortages in most quarters, the Ontario market, as well as the American North-West and

west coast may be potential sales areas for western Canadian coal shipped by rail. For metallurgical and export purposes new developments in the Crows Nest area and the Fort St. John area indicate good possibilities for respectively CP Rail and the British Columbia Railway to provide unit train service. However, transportation plans for neither area have been worked out as yet.

For sulfur trains the unit train system will be ideal for a long time to come. Sulfur pipelining is possible but very improbable due to the accompanying costs of construction and the efficient existing rail service. The situation for potash and grain will depend to a large extent on the changes which can be made in the marketing and distribution system for both commodities. Pipelining, at this time, does not seem possible in the near future.

It is obvious that, locked in as the west is by its natural and political boundaries, many western commodities can only become competitive with identical or similar products from other regions in the world if they can be transported cheaply over the long distances involved. There exist few areas with large bulk production which are forced to ship their products over distances of at least 700 to 1100 miles before encountering either a port or market area. Because of the presence of rail connections

and low-cost, efficient operation the railroads have contributed to the national economy to an extent which is difficult to measure in its totality. It sould seem that few modes can show a combination of adaptability, capacity and economy as can the railroads. Unit train systems are the most recent development exploiting this combination.

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APPENDIX

CONVERSION FACTORS

1. All tonnages mentioned in this manuscript are stated in "short tons" of material. Reference information in terms of other weights has been converted to that basis according to:

1 short ton = 0.893 long ton = 0.907 metric ton = 2000 pounds av.
1 long ton = 1.120 short ton = 1.016 metric ton = 2240 pounds av.
1 metric ton(ne) = 1.102 short ton = 0.984 long ton = 2204 pounds av.

2. Reference information on potash, commonly stated in short tons of "Potassium Oxide equivalent" (K_2O equiv.) is converted to actual tonnages of potash using the commercial rule-of-thumb, which uses KCl (Potassium chloride as the basic form of potash:

tons K_2O equiv. = tons KCl $\times$ 0.60
tons KCl = tons K_2O equiv. $\times$ 1.67

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